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ABSTRACT

A three-phase exploratory study was conducted to make available to British Columbia schools the best in microcomputer hardware, to assist project coordinators and teachers in the integration of microcomputer courseware into the established curriculum, and to evaluate the project. In the first phase, the Apple II Plus with 48K was selected for use, 12 pilot sites were chosen from the 50 proposals submitted, and inservice training was provided for teachers. The second phase concentrated on the integration of courseware into the curriculum and the development of quality curriculum-related courseware. In addition to serving as a center for the gathering and sharing of information on instructional uses of microcomputers, the project team from JEM Research developed an index of educational courseware for the Apple II, a courseware evaluation instrument for use by curriculum selection committees, and a reference manual with guidelines for courseware development. The third phase, running concurrently with the second, continued research into hardware, software, courseware, and applications; provided field liaison services; and surveyed participants to identify microcomputer uses, teacher preparedness, opinions, and perceived needs. Survey data, conclusions, and recommendations conclude the report. A literature search and a 57-item bibliography are attached. (LLS)

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DISCUSSION PAPER 03/81

INSTRUCTIONAL USE OF MICROCOMPUTERS:
A REPORT ON B.C.'S PILOT PROJECT

Prepared for the Ministry of Education
By Denyse Forman
September, 1981

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In our rapidly changing world, there are a great many factors bearing upon future educational directions. Not the least of these is the continuing development of computer-based instructional technology. It was with a view to keeping abreast of the potential for and the implications of using these tools in British Columbia that the work described in this report was undertaken.

Knowledge gained from this work will be used to establish educational policy with respect to microcomputers in the classroom. Your reactions to this Discussion Paper are therefore appreciated.

Many thanks to all of you who contributed to this work.

Ministry of Education

This report, prepared for the British Columbia Ministry of Education, is published as a Discussion paper in order to stimulate wide reaction to the issues raised and ideas presented.

We encourage you to complete and detach this form and mail it to the Project Planning Centre, Ministry of Education, Legislative Buildings, Victoria, B.C. V8V 1X4, or telephone (604) 387-5409.

Comments:

Date:
Name:
Occupation:
Address:

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Legislative Buildings,
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Instructional Use of Microcomputers:
A Report on B.C.'s Pilot Project

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ACKNOWLEDGEMENTS

The following paper is based upon material submitted to the Ministry of Education by JEM Research as part of the work associated with Phase III of the Ministry's Instructional Uses of Microcomputers Pilot Project. Members of the Project Team wish to thank the thousands of students and hundreds of British Columbia teachers who gave of their time so readily to participate in the Pilot Project. Particular thanks go to the coordinators of the twelve participating school districts.

Thanks also to Dr. Barbara Holmes of B.C. Research, and Dr. Deborah Johnson for conducting the summative evaluation upon which the results are based.

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The Pilot Project

Background

The Instructional Uses of Microcomputers Project had its beginnings when a number of educators, some of whom had been using computers in education since 1965, began to petition the Ministry of Education in British Columbia with requests for an investigation into the potential uses of computers in the education system in the province. They wanted to:

1) Ensure that an acceptable standard of computer literacy was available to the students of the province;

2) Employ available technology in a reasoned and appropriate manner for the general enhancement of education; and

3) Answer the requirements of members of the educational community who had perceived both a problem and a need at the school level and who wished to work towards a resolution.

In short, it was felt that there was an immediate need for a serious, systematic attempt to familiarize students with computers, to dispel the mythology surrounding computers, to ensure the opportunity for computer literacy through the education system, and to explore the instructional and management potential of the computer in an educational setting.

The province had not made a heavy financial commitment to timeshare systems and considering the relatively small population, the geographic area, and the remoteness of many of the school populations, it was concluded that an extensive timeshare system was not an appropriate direction for British Columbia at this time.

However, it was brought to the Ministry's attention that recent developments in computer technology, particularly microcomputer technology, indicated that computer assisted instruction was not only a realistic but an economic proposition as well, and supporters of the use of microcomputers in education pointed out the outstanding success of MECC, the Minnesota Educational Computing Consortium, which had been exploring the potential of the microcomputer in education for a number of years.

Further investigations and a visit to Minnesota by representatives from the Ministry, JEM and the school system resulted in a decision to design a project to introduce microcomputer technology into the schools of B.C. along a model developed by MECC who extended their full cooperation and encouragement and offered to B.C. the benefits of their experience.

Purpose

The purpose of the project would be to make available to the schools of B.C. the best in microcomputer hardware in a manner consistent with the requirements of the Ministry and the needs of teachers. The primary emphasis was to be the integration of this technology into the provincial curriculum. In addition, the Ministry was determined to ensure that the introduction of microcomputer technology would be accomplished in a coordinated and carefully controlled manner to avoid duplication of effort and to benefit from shared information and resources.

The selected approach to the introduction of microcomputers to the schools of B.C. was based on a number of factors emerging from initial background work, prior to project formalization. Included in these factors, were the following:

1) the need to generate information on the variety of ways in which microcomputers assist teachers in the instructional process;

2) the need to discover advantages/disadvantages of the machines as a learning/teaching resource, the range of successful applications and requirements of teachers and students in relation to hardware/software configurations;

3) the indication from a number of sources (background research, interviews) that the traditional research design was not necessarily appropriate at this stage;

4) the requirement for flexibility so that the objectives of the field test could be met;

5) the limitation in available resources, requiring a high degree of local initiative, enthusiasm and self-evaluation;

6) the judgement that teachers themselves were able to develop meaningful, site-based criteria for the instructional use of microcomputers, based on

their involvement in the pilot study (there were certain reporting requirements, but these were not intended to be restrictive);

7) the need to evaluate various applications over a reasonable time-period (shop, library, resource centre, classroom contexts);

8) the need to allow freedom for teachers to develop their expertise and to experiment in a classroom setting.

The pilot project was designed to answer a number of general questions, including the following:

1. What are the various appropriate uses of the microcomputer as a teaching tool?

2. What kind of support services and resources are required to maintain a reasonable level of integration?

3. What are the requirements for pre-service and in-service training?

4. What level of coordination is needed for courseware development and courseware integration into the established curriculum?

5. What is the most productive way of deploying microcomputers in a school?

6. What number of machines are required to meet the needs of different kinds of organizational structures and different instructional purposes?

7. What is the best means of sharing the results of software development efforts throughout the province?

Directions for Phase I

A proposal for a project relating to the instructional use of microcomputers and taking into consideration the factors emerging from initial background work, was submitted to the Ministry of Education by JEM Research.

The confusing proliferation of models of microcomputers on the education market and the need for compatibility and quality control throughout the province dictated the initial direction for Phase I of the project.

A decision had to be made as to which microcomputer would be used. A list of requirements was drawn up and the microcomputers that are in fairly widespread use by educators in North America - the Apple II, the Commodore PET, the Radio Shack TRS-80, the Atari, and the Intecolor were evaluated by members of the Project team.

In addition, members of the team began to locate sources of courseware for each of the above models and to evaluate available programs as to the quality of the instructional design, the effective use of the microcomputer, and the compatibility with the goals and objectives of the B.C. curriculum.

The Apple II Plus with 48K was chosen as the microcomputer which would be used in the Pilot phase of the project. This Phase would see the introduction of 100 microcomputers with single disk drives into selected sites to evaluate the usefulness of microcomputer technology in an educational setting and to gather information on the basis of which the Ministry would establish a policy for the possible introduction of microcomputers into the schools of B.C.

The Apple II was chosen for the project for a number of reasons. A major concern in the selection process was the availability of courseware. In addition to a number of other good sources, MECC was using the Apple II and had developed an extensive library of educational programs which they offered to make available to B.C. along with written materials which have proven to be of invaluable assistance to educators in the province.

In addition, the Apple II could display material in a wide range of colours on standard TV screens or on colour video monitors. At that time, neither the TRS-80 nor the PET offered colour capabilities. The Apple II also could be programmed in both high and low resolution graphics; its modular construction in high impact resistant plastic made it light weight and easily transportable; it offered an RS232 interface so that it could be used as a terminal for such networks as NATAL 74 and the CYBER 70; firmware for the use of high level languages beyond BASIC was available; the engineering design allowed for a wide range of peripheral input-output devices such as a microphone and speakers for speech, and graphics tablets which could be easily connected and readily used; and it came with excellent manuals to enable teachers to set up the equipment and begin to learn to program.

Although plans for a continuous evaluation of available microcomputer technology were included in the project plan, a recommendation that because of the clear advantages and greater flexibility of the Apple II, arrangements should proceed to acquire 100 microcomputers to explore the utilization of computer assisted and managed instruction in B.C. schools in a Pilot Project of a year's duration.

The British Columbia Systems Corporation was made responsible for the acquisition and distribution of microcomputers to the schools; the Universities and Colleges were to be involved in the in-service and training aspects of the project; the school districts were to submit proposals as to how they might utilize a specific number of microcomputers; JEM Research was to provide overall support and coordination for the project and the facilties for ongoing research, testing and evaluation of hardware and software; and the Ministry was to provide the support of the Curriculum Development Branch, cost-shared funding with the Pilot districts on microcomputers and a selected list of peripherals, and funding for JEM's participation in the Pilot.

An invitation was extended by the Ministry of Education for school districts to tender for the use of a limited number of machines (about 100), for classroom use, in an exploratory and creative manner. The tendering process required a commitment from teachers in the form of a proposal as to how the microcomputers would be used in the district.

Fifty of the province's 75 school districts submitted proposals and 12 districts were chosen as Pilot sites. In making the selection the following aspects were considered:

1) the uses which teachers or groups of teachers planned for the equipment, i.e. computer assisted instruction including remediation; enrichment, tutorials, simulations, and drill and practice; computer managed instruction; computer assisted testing; administration; computer literacy; and computer science;

2) the context of the application, i.e. classroom, learning assistance centre, laboratory, resource centre, library;

3) location i.e. urban and rural; and

4) level i.e. elementary, junior secondary and senior secondary.

Although computer assisted instruction was the use preferred by the Ministry, the selection of Pilot sites was made on the basis of a wide variety and range of applications, contexts, locations and levels and with regard to the resources available to ensure the implementation of the district's proposal. The pilot project was to be an exploration and the teachers were to feel free to investigate the capabilities and the limitations of the microcomputer in education.

Directions for Phase II and Phase III

Pilot participants and initial directions for the Pilot segment of the project were announced in March 1980 and Phase I was complete. Its conclusion carried with it recommendations for the continuation of the project in two Phases:

> Phase II would concentrate on the integration of available courseware into the established curriculum and the development of quality courseware relevant to the B.C. curriculum; and
>
> Phase III would be a continuation and an expansion of Phase I activities and would provide field liaison; continued research into hardware, software, courseware, and applications; and an evaluation of the project.

The goal of Phase II was to provide teachers with support in augmenting the established curriculum with microcomputer based materials. Curriculum support involved three concurrent focuses of activity:

1. the integration of commercially available courseware into the established curriculum;
2. the encouragement of the development of courseware relevant to the B.C. Curriculum; and
3. planning for the long range integration of curriculum-specific courseware into the learning environment of the province.

Phase III was to consist of the following components:

1. the testing and evaluation of hardware and software on a continuing basis both in a lab and a field setting.
2. the development and establishment of a procedure for evaluation to ensure consistency of standards

across all areas of curriculum.

3. the definition and publication of courseware development standards.

4. the bringing together of the various agencies able to offer in-service to the field.

5. field support to provide reassurance, information and technical assistance.

6. the continued support of the Project team as a coordinating agency for the distribution of information concerning microtechnology and new technology advancements to the field.

7. the formative and summative evaluation of the Pilot Project.

Phases I, and III Project Support Activities

The Pilot teachers' involvement in Phase I activities began in the summer of 1980 with the University of Victoria and the University of British Columbia's providing a one week workshop to familiarize Pilot participants, many of whom had never seen a microcomputer, with the Apple II.

The in-service and training of teachers in B.C. with microcomputers was continued throughout the year with the Universities and Colleges providing one day, evening and weekend workshops for both Pilot and non-pilot school districts. The University Extension division of the University of Victoria has established a continuum of skills which takes the workshop participant from an introduction, to setting up and maintaining the hardware, through purchasing, running, evaluating and integrating commercially available courseware, and on to the development of programs using teacher aids, authoring languages, BASIC, and Pascal. They call upon the services and the expertise of computer experts in the field, the universities and the colleges, the dealers marketing educational microcomputer products, and personnel from the Project team.

When the Apples arrived in the school districts in August, theoretically the teachers were familiar with the hardware and had previewed and worked with many of the educational programs available on the market at that time.

In addition, they received a 400 page Reference Manual developed by the Project team to provide support for the integration of available courseware into the B.C. curriculum. It was believed that in the first six months of the project teachers new to microcomputers would need time to become comfortable and confident with the technology and would primarily be using courseware available from the commercial developers.

The manual contained an introductory section to help teachers set up the equipment and to run a program; a guide to selecting and purchasing courseware; an index of approximately 500 programs divided into subject area and grade level; a section in which courseware catalogues were reproduced; a number of checklists for evaluating programs and applications; a courseware descriptors section which provided teachers with detailed descriptions of approximately 150 programs; and guidelines for reporting on the project.

It was anticipated that there would be a number of teachers already experienced with microcomputers who would be developing courseware and that there would be a need for information on evaluating available programs. To meet these needs, the Reference Manual also contained a "Standards' Guide for the Development of Courseware" which contained guidelines for the authoring of educational programs.

Support services for the participating districts continued throughout the year. The Project team became an information and coordination centre for the gathering and sharing of information relating to the instructional use of microcomputers. 'Micro-scope', a monthly publication, acted as a vehicle for an exchange of information and featured regular articles on microcomputer applications in education, on courseware evaluation and development, and on the latest developments in hardware and programming utilities. Current journals and magazines were researched regularly and through bulletins and telephone conversations, districts were kept informed of new developments.

Members of the Project team visited pilot sites to monitor activities and provide support and information and provided a troubleshooting and information service in responding to calls and letters regarding hardware, courseware, and programming difficulties. Through 'Micro-scope' and field visits, a communications link among districts was established, and a conference of Pilot district coordinators facilitated this exchange.

Arrangements with MECC were finalized and all Pilot districts received all available diskettes and documentation. Bulk purchase and the "right to copy" arrangements with other distributors were also investigated. Courseware was continuously evaluated and the results were sent to the Pilot districts and were published in 'Micro-scope'. In addition, whenever possible, courseware was demonstrated on field visits to the Pilot sites.

The Project team helped coordinate and participated in workshops throughout the province, and planning for in-service activities and credit and non-credit courses to accomodate changing needs continued in cooperation with the colleges, universities and school districts.

Phase II Project Support Activities

Phase II of the project ran concurrently with Phases I and III. The purpose of Phase II was the integration of commercially available courseware into the B.C. curriculum and the support of courseware development efforts in the province. The Project team's work in this area was closely monitored and supported by specialists from the Ministry of Education's Curriculum Development Branch.

In order to facilitate the integration of courseware into the B.C. curriculum, members of the Project team located and assigned to subject area and grade level approximately 1,000 educational programs for the Apple II. The first index was published in Volume I of the Reference Manual and a computerized index, using the Apple II, was kept up to date at all times. A second revised edition of Volume I was published in July 1981.

The second stage in the integration of courseware was the evaluation of currently available programs. The Project team and the Curriculum Development Branch developed an evaluation instrument which would permit curriculum selection committees to evaluate microcomputer materials with reference to their educational value, their relevance to the B.C. curriculum and the effective use of the microcomputer. Until the Ministry had established a policy concerning the use of microcomputers in the schools of B.C., the courseware which "survived" the materials selection committees would be listed as "supplementary" to the curriculum rather than "approved" or "authorized".

At the same time, courseware descriptors were provided for teachers in the field through Volume I of the Reference Manual, through regular bulletins, and through the monthly publication, 'Micro-scope'. In addition, articles suggesting ways in which microcomputers might be used in specific subject areas were included regularly to aid teachers in integrating courseware into their own programs.

In this manner, a "curriculum map" was developed which provided the Curriculum Development Branch, members of the Project team, and teachers in the field with information regarding areas where courseware was available and where there were gaps.

Educational publishers were contacted with regard to areas in the B.C. curriculum which might be augmented with microcomputer materials, and where there might be improvements in the courseware they had already published; and gaps were advertised to the field.

In order to facilitate the local development of curriculum specific courseware, the Ministry established a Courseware Development Fund which provided "seed" money to teachers who were interested in developing programs in areas which were approved by the Ministry. Programs developed through this Fund became the property of the Ministry of Education which owned the right to distribute the programs within the province of B.C. although the author retained distribution rights outside of the province.

To assist teachers in authoring courseware, a "Standards' Guide for the Development of Courseware" was published in July of 1980 and a revised and expanded version was published in September, 1981.

The "Standards' Guide" was followed in March, 1981, with Volume II of the Reference Manual. Where Volume I provided support for the integration of commercially available courseware, Volume II was published to provide support in the development of courseware.

Volume II discussed advanced programming techniques in BASIC; included a detailed description of Pascal and how it can be used to develop courseware; provided a comparison chart of Pascal and BASIC; gave an overview of assember editors; described what to look for in an authoring language and compared in detail a number of available languages; and offered an evaluation of five microcomputer systems as compared against a set of hardware criteria.

Under the direction of the Curriculum Development Branch, the Project team developed a number of exemplary programs which were used to demonstrate development standards and which filled specific courseware gaps in the B.C. curriculum. These were used to test a procedure for fully integrating courseware into the established curriculum.

Project Evaluation

The Project team's activities during the past two years represented the Ministry of Education's carefully planned investigation into the potential usefulness of microcomputers in education. The information gathered would be the basis for a decision on the procedures, policies and support services which would need to be established if the Ministry were to support the widespread introduction of microcomputers into the schools of B.C.

Formative Evaluation

Purpose of Evaluation

It was felt that halfway through the Pilot project, teachers and coordinators were in the position of having enough information and experience to be able to provide the Ministry with some tentative answers to the questions posed at the beginning of the Study.

Further, it would provide the Project team with information on the status of present support services described above. It was intended that the survey indicate where services were adequate, where they needed augmentation or redirection, and where activities could be de-emphasized.

The information thus obtained provided valuable assistance in planning future directions and activities in support of the Pilot and the future use of microcomputer technology in education.

Method

In December, 1980 each Pilot district was sent a questionnaire with a request that each teacher involved in the Pilot study fill in a form. The majority of the questions requested specific information, but a number invited teachers and coordinators to express their opinions on future directions for the support of microcomputers in education in the province of B.C.

As a follow-up, each district was visited for on-site observations and to interview participating students, teachers, and coordinators.

Results

The formative evaluation provided an early indication of successes and failures, of frustrations and accomplishments. It was evident that educators in B.C. were highly enthusiastic but were very realistic in identifying areas of major concern that they felt needed to be addressed by the Ministry to ensure the successful widespread introduction of microcomputers into the schools of the province:

1. The single most critical issue in the use of microcomputers in the schools of B.C. was the acquisition, development, and sharing of quality CAI materials relevant to the B.C. curriculum. Educators identified specific concerns and documented the following needs:

    a) the evaluation and description of commercially available courseware with reference to its quality and relevance to the B.C. curriculum;

    b) the documenting of areas where "authorized" commercial courseware correlates with specific areas and levels of the B.C. curriculum;

    c) the negotiating of bulk purchasing arrangements and the right to copy exemplary courseware;

    d) the establishment of a delivery system for making courseware available to the field;

e) the documenting of specific areas and levels where courseware is lacking;

f) the continued support of an organization dedicated to the coordination of the development of a sufficient quantity of quality courseware employing the expertise of subject area and computer specialists, and the resources of the Curriculum Development Branch;

g) the evaluation and distribution of locally developed courseware; and

h) support, either through release time or financial assistance, to teachers or districts working on the development of courseware.

2. A second major concern was that there be established an information network to connect all educators using computers to a central source where information could be collected and disseminated.

3. Educators felt that the Ministry, the colleges, and the universities must continue to support in-service training to provide for the different levels of interest, expertise, and experience of educators within the province.

4. The Pilot districts also believed that it was essential that the Ministry continue to provide assistance for hardware and peripheral purchase, and to provide assistance both at the district and Ministry level for a coordinator responsible for computer programs within the districts.

Summative Evaluation

Methodology of Summative Evaluation

The Project team sought external assistance from B.C. Research in conducting the summative evaluation. Two questionnaires were generated (Appendix 1) for distribution to Pilot study coordinators and teachers.

The questionnaires were reviewed and approved by the PRC, a project review committee established by the Planning Centre in the Ministry of Education, in April. They were mailed to the 12 Pilot coordinators and 200 participating pilot teachers in early May. All coordinators responded to their questionnaire, and, a 60.3% rate of response was received from the teacher population. It should be noted that the 60.3% rate of response was the percentage of returned questionnaires from an estimated total that were mailed out (53). The rate of response was better from urban districts possibly reflecting either a poor estimate of the number of teachers involved in the rural districts, or a deficiency in communicating with rural districts. However, no district was unrepresented in the body of teacher responses. (On some of the figures and tables, the total number of coordinator responses will not total twelve nor will the percentage of teachers total one hundred due to their omission of that particular item.)

Results

The two populations surveyed can be profiled according to: 1) the use of the microcomputers, 2) preparedness, 3) opinions, and 4) perceived needs.

The Use of the Microcomputers

Figures 1-4 and Tables 1-5 provide data relative to the overall use of the microcomputers by the pilot study teachers and coordinators.

The teacher population generally had access to an average of 4.0 microcomputers at the senior secondary level, 4.4 at the junior secondary level, 2.0 at the intermediate level, and 2.4 at the primary level (54). From these results, it can be safely assumed that the information gathered reflected the experiences and opinions of the full range of teachers from K-12.

However, although teachers from all grade levels were represented, almost half of the 100 microcomputers in the project were used at the intermediate level with only 9% used at the primary level. A factor that could possibly account for this heavy use at the intermediate level is the availability of CAI materials at this level. A year ago, when the pilot proposals were designed, very few programs for primary students were available and this, combined with primary students' lack of familiarity with a keyboard and their lack of experience in working independently, probably accounts for the low percentage of use at the primary level.

While only 4.4% of the pilot teachers had access to the microcomputers for less than a week, 64% had access for six months or more (Figure 1). This suggests that the majority of the participating teachers had adequate opportunity to explore the instructional potential of the microcomputer and to recover sufficiently from the Hawthorne effect to be able to provide a fairly objective assessment of the microcomputer's impact on the learning environment.

The twelve pilot district coordinators had responsibility for an average of nine schools with access to 11.5 microcomputers.

Cross tabulation analysis reveals that at the elementary level, almost all microcomputers were located in classrooms or libraries with the majority being located in the regular classroom. This location would appear to be consistent with further findings of this project that the major use at the elementary level was CAI, most frequently of the drill and practice type, in the basic skills areas of mathematics, language arts, social studies, and science, with regular students.

At the secondary level where the microcomputer was used most frequently in physics and computer science, the microcomputer locations were split evenly between classrooms and computer labs (Figure 2).

When asked to give their opinion on what they believed to be the most important use of the microcomputer (on a scale of 1-4 with 1 being the most important use), the responding teachers indicated that they felt that regular curricular augmentation was the most important use (1.77), followed by administrative record keeping (2.75), teacher training (2.68), and courseware development (2.55).

In actual use, the microcomputer was used 64.4% of the time to augment instruction, particularly at the elementary level (Figure 3) (Table 1). However, as the grade level increased so did the time devoted to using the microcomputer to provide instruction not previously available. Indeed, the majority of senior secondary students used the microcomputers for that purpose. For example, in rural districts where previously there was no access to computer facilities, the microcomputer was able to provide instruction in computer science that the district had not been able to offer prior to the pilot project.

The microcomputer's ability to provide instruction in areas where such instruction was not previously available - in 30% of cases - argues for its cost effectiveness in broadening and equalizing educational opportunities for rural and disadvantaged students.

The microcomputer was used to replace traditional instruction in only 1.1% of cases. This small percentage is probably due to the majority of the available courseware being what is termed by Chambers "adjunct" courseware, designed to augment rather than replace traditional instruction. It might also suggest that teachers' fears that the computer will replace them in the classroom appear to be unfounded. Rather, it confirms the use of the computer as a tool to assist the teacher.

The second major use for the computer was for courseware development (17%), followed by teacher training (8%), and administrative record keeping (2%). This order of uses was perhaps influenced by the Ministry's announcement that they preferred districts to use the microcomputers for creative and innovative applications rather than for administration purposes.

It is interesting to speculate on the reasons why the microcomputers were used only 17% of the time for courseware development although teachers identified it as an important use of the microcomputer.

There are a number of factors that might account for this:

1. Time In the formative evaluation teachers requested financial assistance and release time to upgrade their skills and develop courseware.

2. Access to Microcomputers The limited access teachers had to the microcomputers was considered to be a major impediment to the teachers meeting their objectives. If the computers were used 64.4% of the time to augment instruction, little microcomputer time was available for courseware development.

3. Incentives The courseware development fund which was to provide the incentive for B.C. specific courseware was the least used support service in the project.

4. Experience The senior secondary teachers, 50% of whom had previous computer experience as compared to 6% for primary teachers, used the microcomputers 31.2% of the time for courseware development. Over one third of the pilot teachers had had no computer experience or training prior to their participation in the pilot.

5. Interest Ninety-five percent of the teachers and all of the coordinators were highly enthusiastic about a continued involvement with microcomputers in education (Figures 17 and 18), and the majority of the participants requested future in-service training in topics relevant to courseware development (Table 16).

6. Availability of Commercial Material It is interesting to note that the intermediate teachers who used the microcomputer for CAI the most (possibly because of the quantity of courseware available at this level), used the microcomputer the least for courseware development, suggesting perhaps that when courseware is available commercially, teachers do not feel the need to develop courseware.

It appears that lack of access to the microcomputers, lack of time to develop courseware, and lack of experience were the major factors in the low emphasis on courseware development among the participating teachers. It is interesting to note that the financial incentive of the courseware development fund did not promote courseware development in the province.

Any such speculation as to the reasons why teachers spent so little time in developing courseware is crucial to the future of the instructional uses of microcomputers since it is generally agreed that the lack of a sufficient quantity of good courseware has been a major impediment in the widespread proliferation of CAI.

In addition, the summative evaluation found that at the primary, intermediate, and junior secondary levels, the subject area in which the computer was used most often was in mathematics. The second major use was in language arts followed by social studies and science. At the senior secondary level, the major subject area for microcomputer use was in physics followed by computer science, chemistry, business education and data processing (Tables 2 & 3).

The use of CAI in these subject areas is consistent with the availability of courseware in these areas and perhaps also reflects the schools' concern with augmenting instruction in the basic skills areas.

CAI was used with regular students in over two thirds of the cases except at the junior secondary level when it was used for regular students 47.8% of the time and for remedial students 23.9%.

The use of the microcomputer approximately one quarter of the time at the junior secondary level to provide remediation suggests that the microcomputer's demonstrated ability to provide patient, individualized drill and practice was taken advantage of to remediate junior secondary students in basic skills areas. This may indicate that junior secondary teachers were able to provide remediation which they might not have been able to offer without the assistance of the microcomputer as an instructional tool.

At the primary, intermediate, and junior secondary level, the major emphasis in microcomputer applications was in drill and practice followed by educational games. At the senior secondary level, the emphasis shifted to problem solving followed by drill and practice and tutorial applications (Table 4).

Again, the emphasis in applications probably was dictated by the availability of courseware and also by the nature of instruction at that level. Elementary schools generally spend a considerable amount of time in providing drill and practice on skills and concepts introduced by the teacher. Certainly, the majority of CAI programs on the market at the elementary level are drill and practice programs in the basic skills areas.

At the secondary level, many of the programs on the market provide demonstrations, simulate laboratory situations or manipulate data that has been entered by the student. The emphasis at the secondary level on problem

problem solving in instruction and the availability of programs which can be used in problem solving likely account for the emphasis on this CAI application at the senior secondary level.

Across all levels, the computer was used 64% of the time for regular students, 15% for remedial students, 10% for the gifted, and the remainder of the time for the physically disabled and the emotionally disturbed (Table 5).

Although some researchers have argued that the best use of the microcomputer is to provide instruction for students disadvantaged in the regular learning environment, the majority of the participating teachers in the pilot project used the microcomputer in their regular classroom, to augment the tradi

FIGURE 1

ACCESS TO MICROCOMPUTERS

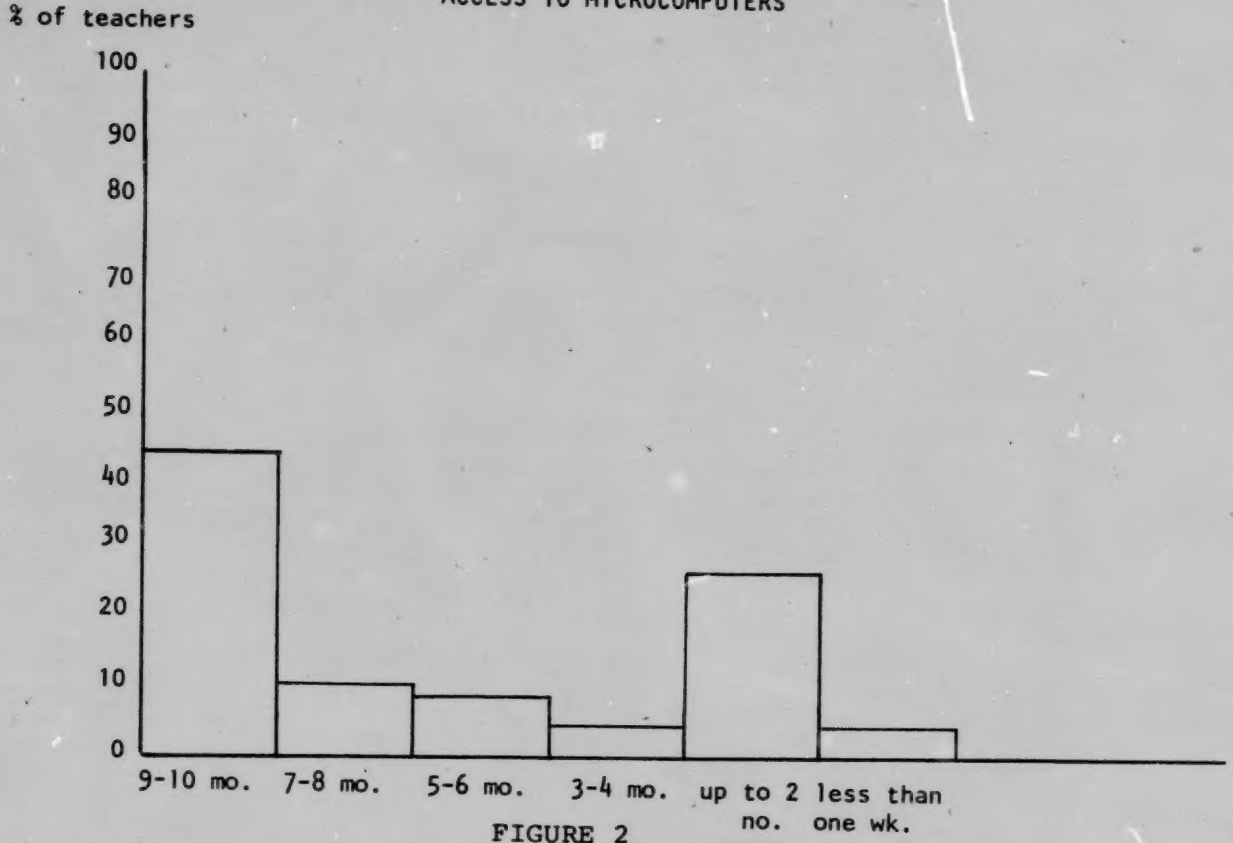
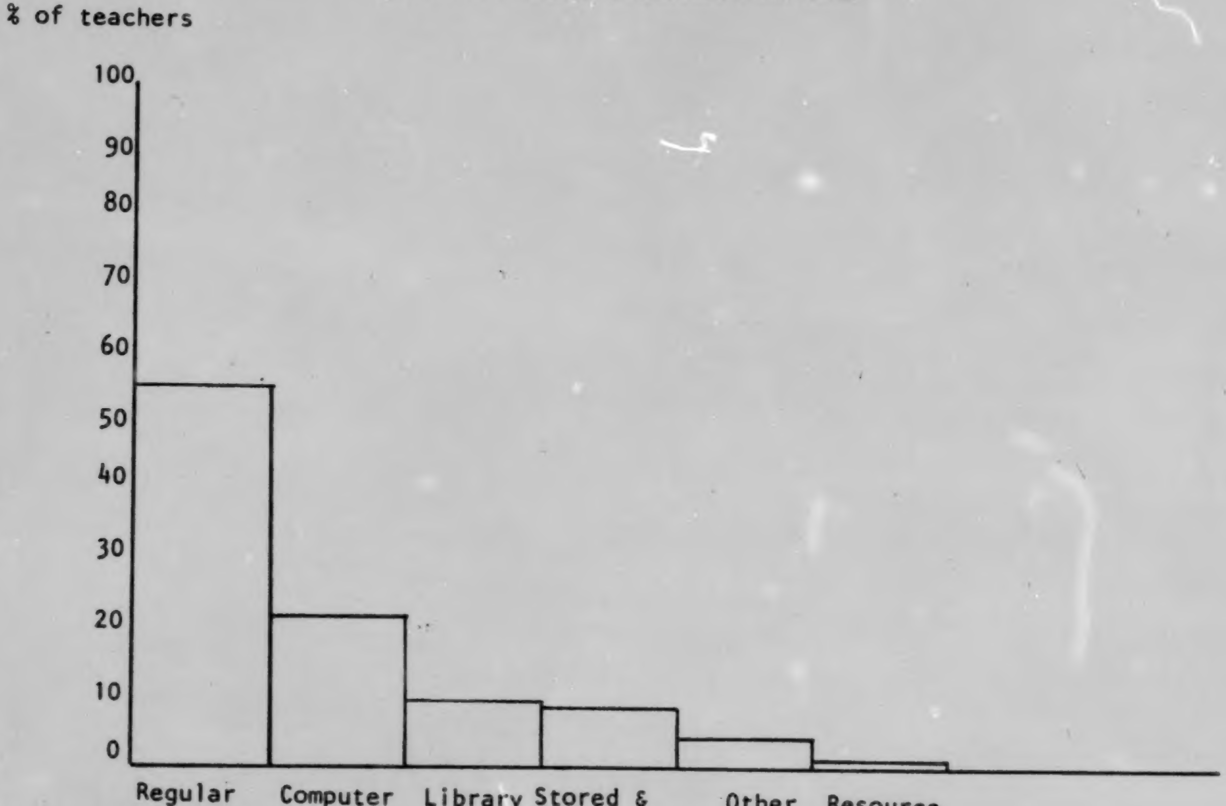


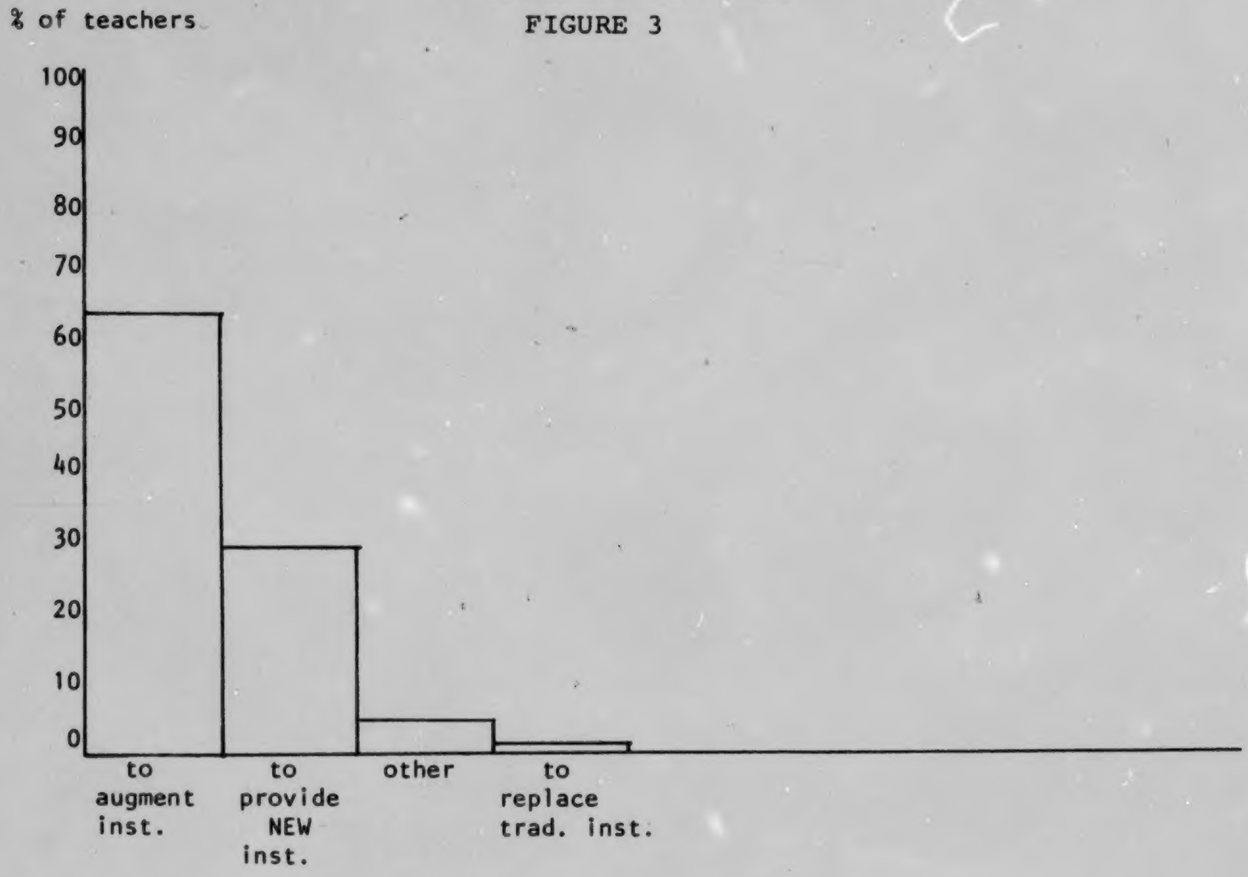
FIGURE 2

LOCATION WHERE MICROCOMPUTER USED



USE OF MICROCOMPUTERS

FIGURE 3



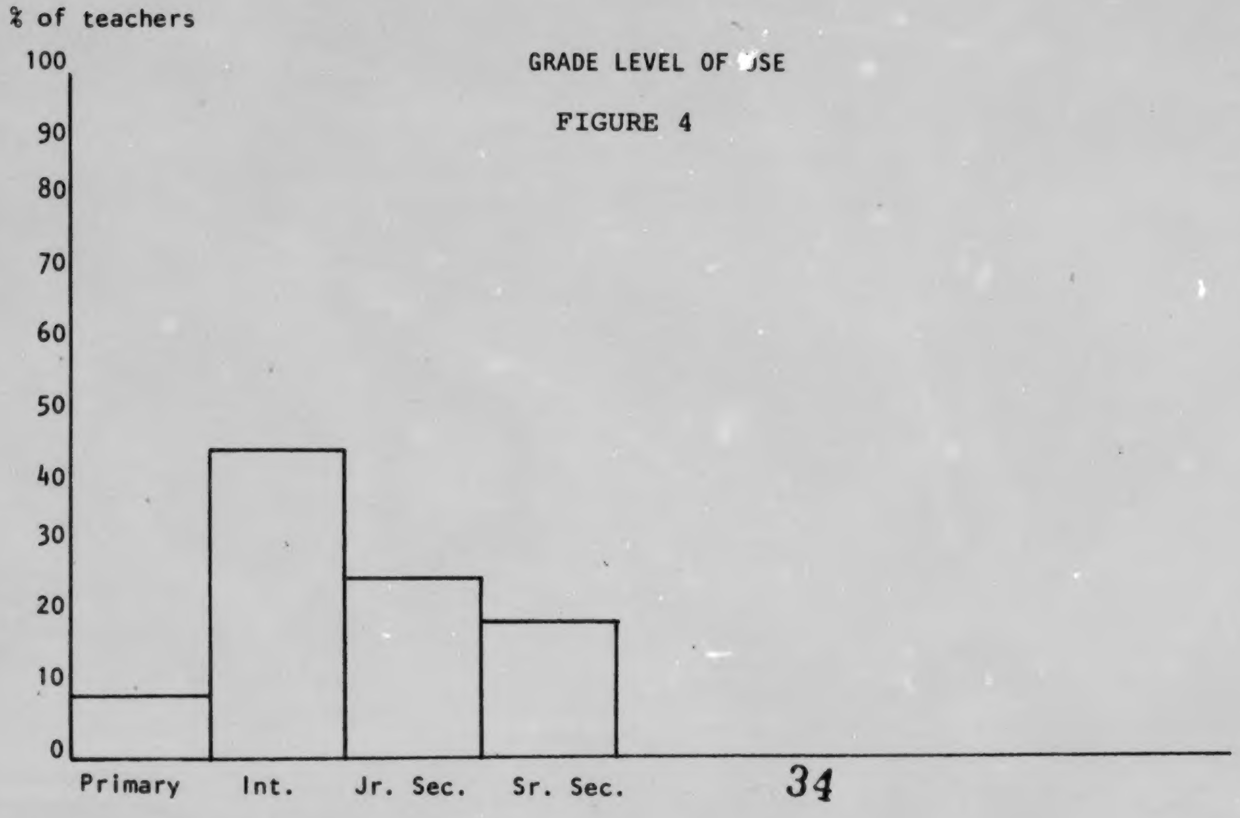

GRADE LEVEL OF USE

FIGURE 4

TABLE 1

SCHOOL USE OF MICROCOMPUTERS

PERCENTAGE OF TEACHERS MATRIXED ACCORDING TO USE AND SCHOOL LEVEL

	Primary	Intermediate	Jr. Sec.	Sr. Sec.
Admin. Record Keeping	0.0	0.5	2.2	2.8
CAL	54.3	76.5	51.5	60.9
Teacher Training	10.3	6.4	10.5	9.6
Courseware Development	10.0	8.9	20.6	31.2

TABLE 2

PERCENTAGE OF TEACHERS ACCORDING TO GRADE LEVEL AND SUBJECT AREA

Elementary was used when the grades listed spanned primary and intermediate. Secondary was used when the grades listed spanned junior and senior secondary.

	ELEM.	PRI.	INTER.	SEC.	JRSEC.	SRSEC.
Art	0.9	0.9	2.6		1.7	
Business Education			0.9	1.7	5.1	2.6
Chemistry			0.9	0.9	0.9	2.6
Computer Science	0.9		8.5	3.4	8.5	4.3
Data Processing			2.6	1.7	0.9	2.6
English	0.9	0.9	10.3	0.9	8.5	
Foreign Languages			3.4		1.7	
Industrial Arts					0.9	0.9
Language Arts	5.1	5.1	17.9		2.6	
Mathematics	11.1	7.7	29.1	5.1	18.8	3.4
Music	0.9		10.3	0.9	1.7	0.9
Physics	0.9		0.9	0.9	0.9	5.1
Science	2.6	0.9	15.4	2.6	6.0	0.9
Social Studies	3.4	2.6	17.9	0.9	7.7	

TABLE 3

PERCENTAGE OF TEACHERS ACCORDING TO INSTRUCTIONAL USE AND SUBJECT AREA

	Regular	Remedial	Enrichment	Computer Literacy
Art	2.6		2.6	5.1
Business Education	7.7	3.4	4.3	6.8
Chemistry	2.6	2.6	4.3	1.7
Computer Science	9.4	3.4	7.7	20.5
Data Processing	4.3		0.9	6.0
English	11.1	10.3	8.5	2.6
Foreign Languages	1.7	1.7	4.3	0.9
Industrial Arts			0.9	0.9
Language Arts	18.8	12.0	17.9	10.3
Mathematics	51.3	41.0	44.4	30.8
Music	6.8		12.0	5.1
Physics	6.0	0.9	6.0	1.7
Science	16.2	3.4	23.9	6.0
Social Studies	19.7	7.7	19.7	6.8

TABLE 4

PERCENTAGE OF TEACHERS ACCORDING TO APPLICATION AND SCHOOL LEVEL

	Primary	Intermediate	Jr.Sec.	Sr.Sec.
Classroom Management	0.2	3.5	5.2	1.8
Worksheet Generation	0.1	1.1	3.2	2.3
Drill and Practice	40.0	34.6	30.8	19.3
Simulation	1.4	11.4	6.4	8.9
Tutorial	6.7	8.3	5.2	11.2
Educational Games	20.00	22.5	16.0	7.0
Problem Solving	13.3	7.7	9.0	33.6
Testing	2.4	4.2	2.4	1.9

TABLE 5

PERCENTAGE OF TEACHERS ACCORDING TO TYPE OF STUDENT AND SCHOOL LEVEL

	Primary	Intermediate	Jr.Sec.	Sr.Sec.
Regular	76.7	68.3	47.8	71.4
Remedial	8.9	12.0	23.9	14.1
Gifted	5.6	9.6	11.6	9.6
Handicapped	0.0	2.4	5.0	0.9

Preparedness of Pilot Participants

Thirty-seven percent of the responding teachers and 1 of the 12 coordinators reported having had no previous experience prior to their involvement in the pilot project (Table 6).

Approximately one fifth of the responding participants had taken university or college computer courses or had previous computer experience (Table 7). The higher the grade level, the greater percentage of teachers had had prior experience with computers. This ranged from 50% of senior secondary teachers to 6% of primary teachers.

Teachers estimated their computer literacy level at 2.7 (on a 5 point scale with 1 being the lowest), whereas coordinators estimated that they had a computer literacy level of 3.4 (Figures 5 & 6). Secondary teachers, reflecting their prior experience with computers, rated their computer literacy higher than did elementary teachers.

Over 65% of the teachers and 10 of the 12 coordinators felt that during the course of the year they had been self-trained (Table 7).

After an initial jointly sponsored workshop involving personnel from the Ministry and the Universities in May, the participating pilot districts were responsible for organizing in-service training for their own teachers. Table 7 indicates that 54.5% of the responding teachers and 6 of the 12 coordinators participated in local, district sponsored in-services. The coordinators generally were responsible for the organization of district in-service offerings.

In their "self-training," coordinators and teachers differed in what they found to be useful support services (Tables 8 & 9).

The Project team/Ministry personnel, the monthly publication, "Micro-scope," computer journals and magazines, and the Apple Manual were identified as being "very helpful" by the majority of the coordinators (Table 8).

The Reference Manuals, Volumes I and II, the Project team bulletins, hardware and courseware evaluations and demonstrations, the MECC materials, the Demo diskette, the university based workshops and the Apple Manual were judged to be "moderately helpful" to the majority of the coordinators. Nine of the 12 coordinators did not make use of the courseware development fund and 6 of the 12 did not make use of any of the computer organizations or associations within the province.

The majority of the teachers, on the other hand, did not use any of the items or the services except their local district personnel, the Apple Manual, and a demonstration diskette of programs.

It is significant to note that over 65% of the teachers and 10 of the 12 coordinators felt that they had been "self-trained". This would seem to indicate that either the majority of participants preferred this approach, or that they had been forced through circumstances to learn on their own. As 60% of the teachers and 8 of the 12 coordinators felt that their pre- and in-service training had been inadequate or only partially adequate (Figures 7 & 8), it appears that a quite a number of the participants felt that more provision for pre- and in-service training should have been made. However, it is evident that the districts took on the responsibility for providing workshops and the participating teachers took advantage of whatever opportunities were available to increase their knowledge and experience in this area (Tables 6 & 7).

Subjective unsolicited comments on the questionnaire form indicated that teachers felt that it was their pre-service training before the pilot that had been inadequate in preparing them for their participation in the pilot. The teachers who felt that they were using the pilot year to explore the potential of the microcomputer in an educational setting appeared to be less concerned about the inadequacy of their pre-service training.

It is significant to note that the Ministry's commitment to provide field support for the participating districts through a central support agency appeared to have been an effective and useful approach. As discussed earlier in the report, the central support agency was to provide field support through information collection and dissemination and through the coordination of microcomputer efforts throughout the province. As was indicated in the coordinators' identification of the support services that were used, the items and activities of the central support agency were identified as moderately or very helpful by the majority of the coordinators.

This is also an indication that the type of support services that the Project team provided were what were needed by the coordinators, i.e., a central agency to provide information on computer activities and applications throughout the province, to put people in touch with others who share similar interests and concerns, to purchase and evaluate hardware and courseware and to share this information with the field, and to act as a coordinating agency between the field and the Ministry.

However, very few of the services and very little of the information provided by the Project team were indicated as being used by the participating teachers. This would appear to indicate that the type of information that was provided to the coordinators was not of interest to the teachers, that the information was not relayed from the coordinators to the teachers, or that the information reached the teachers but not in its original form.

Eleven of the 12 coordinators were performing their computer coordinating duties over and above their regular duties in the district. On the average, each coordinator was responsible for 9 schools. In the interviews for the formative evaluation, coordinators repeatedly complained about the lack of time to fulfill their obligations. It is reasonable, therefore, to assume that part of the reason why the teachers did not use some of the items or support services was because the coordinator simply did not have enough time to ensure that all the information was relayed to the teachers in the schools.

It is also very likely that the coordinators shared the information with the teachers but that the teachers were not aware that the information was coming from the source listed on the project evaluation questionnaire. This interpretation would appear to be confirmed by the fact that over 80% of the teachers indicated finding their local district personnel moderately or very helpful.

The teachers and the coordinators' use of the services available to them seems to indicate that it is not reasonable to expect teachers individually to use the resources of a centrally located support agency, but it is reasonable and effective for them to use a resource within their district. Similarly, it would appear that a district coordinator will use a central agency and will be viewed as helpful and useful by the computer using teachers within the district. However, it is evident that for this type of delivery system to work effectively, the communication between the central agency and the coordinator and between the coordinator and the teachers must be guaranteed by ensuring that all the participants have sufficient time and resources to take advantage of the system.

It is interesting to note that both the coordinators and the teachers identified the Apple Manual as a significant resource in their "self-training." As one of the reasons why the Apple was chosen for the pilot was the clarity of the manual for the new user, the Ministry's choice of the Apple appears to be justified in this respect.

COMPUTER LITERACY

FIGURE 5

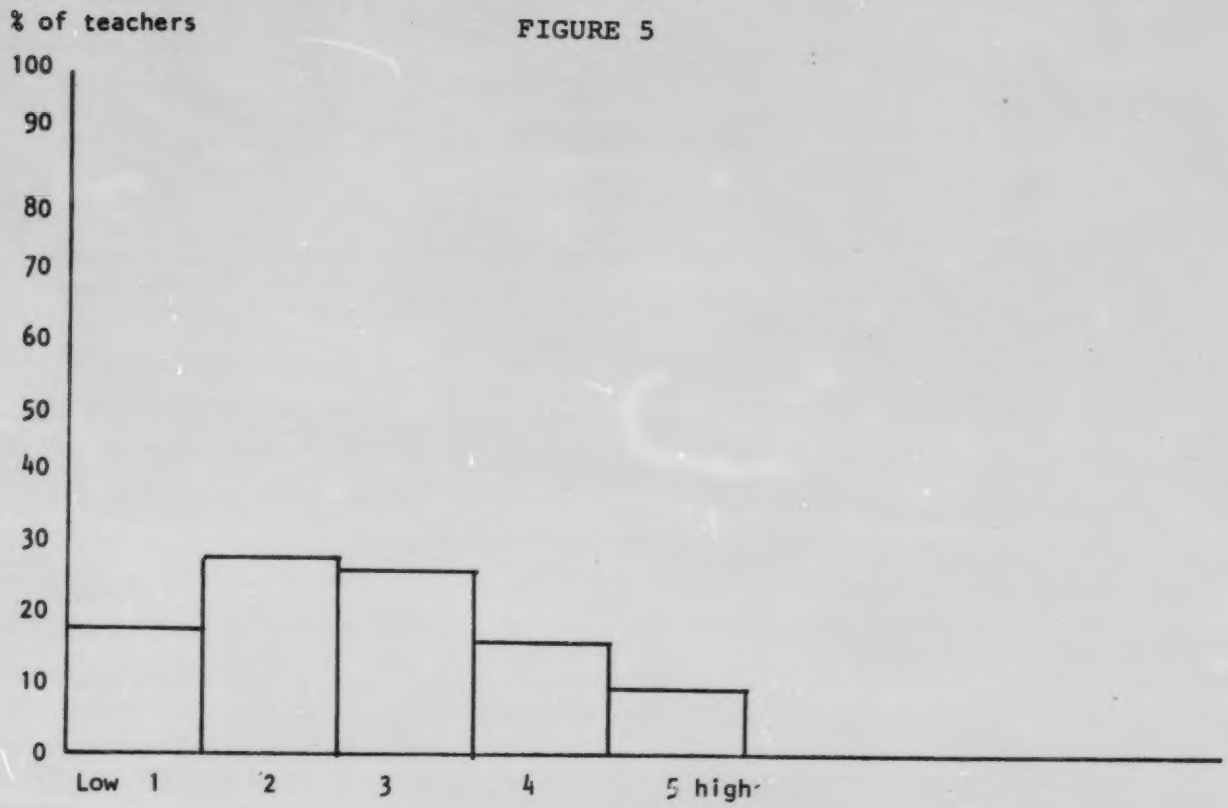
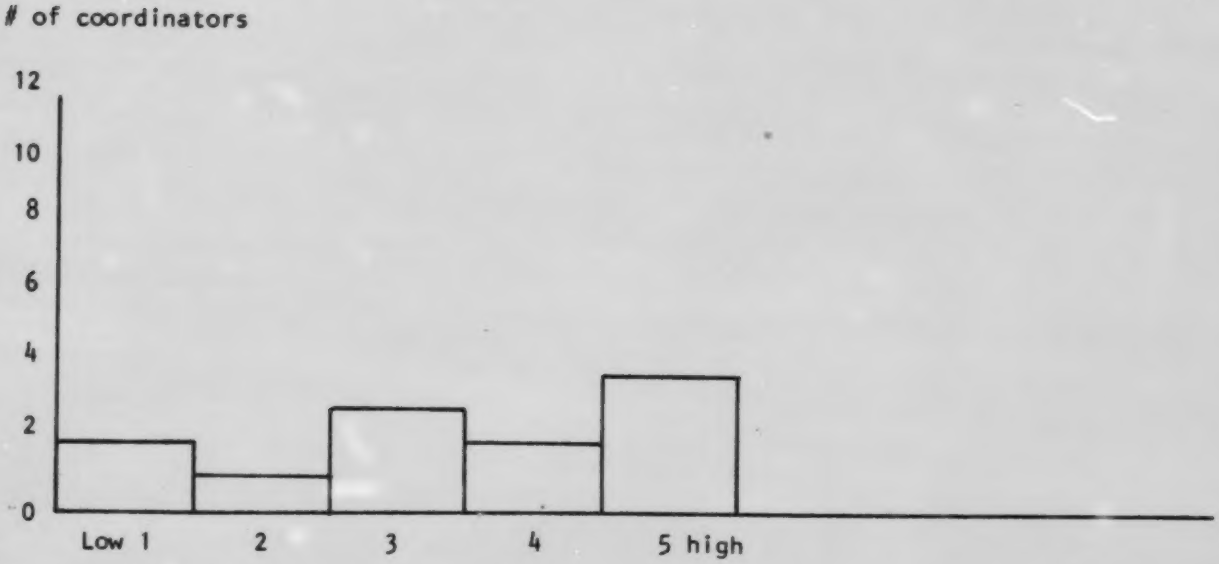


FIGURE 6



ADEQUACY OF PRE- AND IN-SERVICE

FIGURE 7

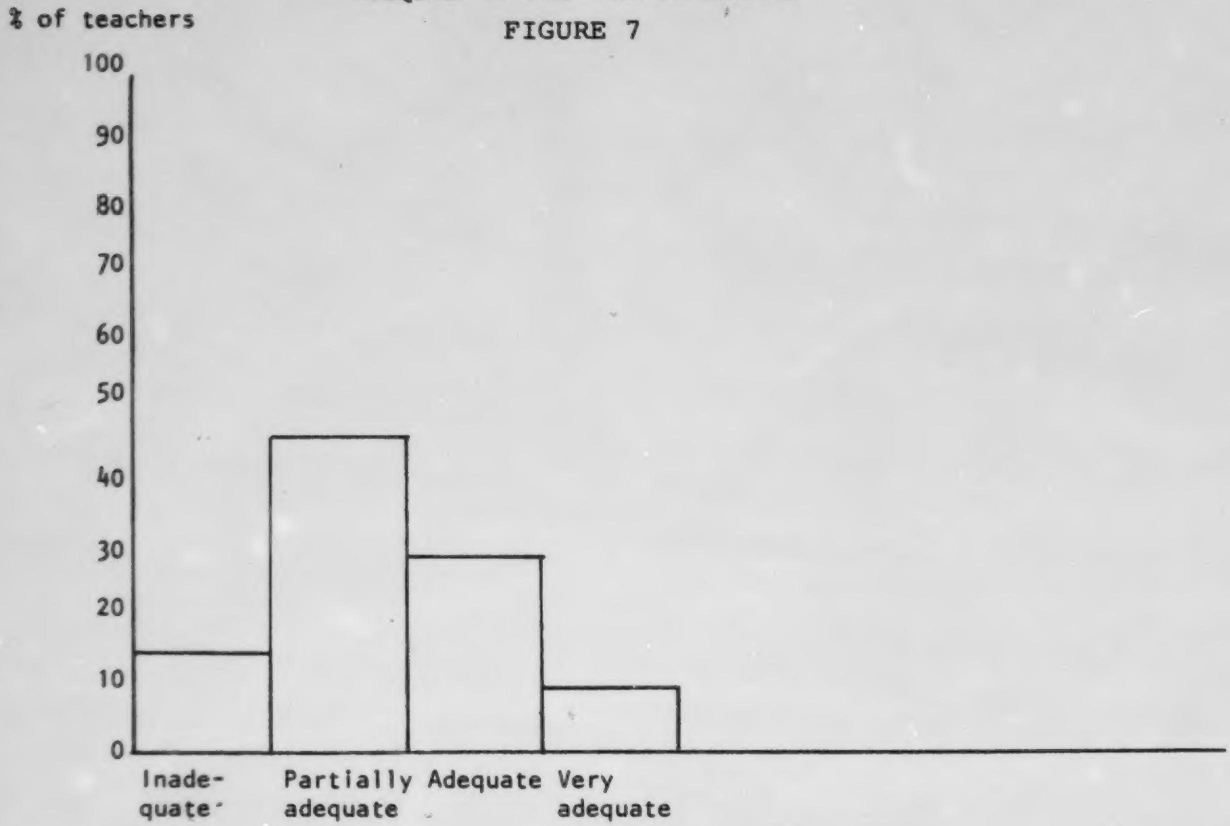


FIGURE 8

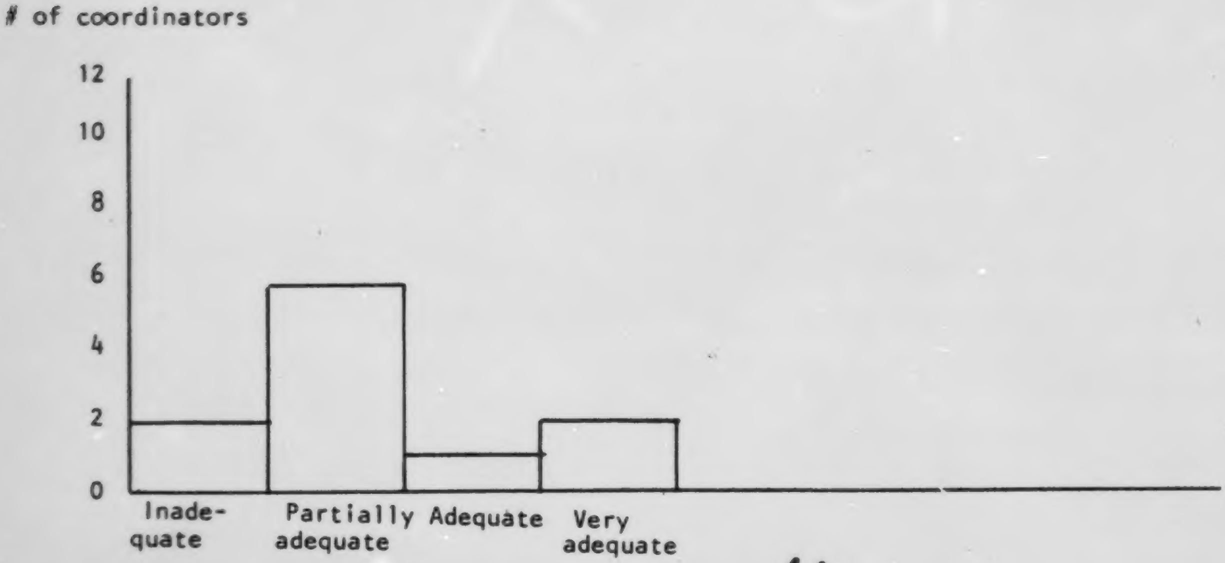


TABLE 6

PRESERVICE TRAINING

	% of teachers	# of coordinators
None	37.4	1
Previous computer experience	18.3	5
University or College computer course	21.7	5
U.B.C. Summer Seminar	17.4	5
U. Vic. Apple workshop	11.3	1
District sponsored workshop	25.2	4
Other	7.0	2

TABLE 7

IN-SERVICE TRAINING

	% of teachers	# of coordinators
Ministry sponsored in-services	9.8	6
District sponsored in-services	54.5	6
Colleague assistance	54.5	6
Self training	65.2	10
Other	9.8	2

TABLE 8

SCHEDULE OF COORDINATORS' USE OF SUPPORT SERVICES

	Not Used	Not Helpful At All	Moderately Helpful	Very Helpful
The Complete Reference Manual for the Instructional Use of Microcomputers	1	0	10	1
JEM Reference Manual Volume II	3	0	6	3
The JEM Demo Diskette	2	1	6	3
JEM Bulletins	1	0	7	4
MICROSCOPE	0	0	5	7
Related journals or magazines	0	1	5	6
JEM courseware evaluations	0	0	7	5
Apple manual	0	0	6	6
MECC courseware	1	0	6	5
Courseware demonstration	2	0	8	2
Courseware Development Fund	9	1	1	1
Local district personnel	3	0	5	4
JEM Research Team/ Ministry personnel	0	0	4	8
Other organizations or associations (please specify)	6	0	4	2
University-based workshops	3	0	6	3
District-based workshop	3	0	4	5
Other (please specify)	11	0	1	0

TABLE 9

SCHEDULE OF TEACHERS' USE OF SUPPORT SERVICES

	Not Used	Not Helpful At All	Moderately Helpful	Very Helpful
The Complete Reference Manual for the Instructional Use of Microcomputers	41.0	2.9	42.9	13.3
JEM Reference Manual Volume II	50.5	4.0	40.4	5.1
The JEM Demo Diskette	22.8	5.9	47.5	23.8
JEM Bulletins	51.0	7.1	33.7	8.2
MICROSCOPE	45.6	7.8	37.9	8.7
Related journals or magazines	49.0	6.0	33.0	12.0
JEM courseware evaluations	48.5	14.1	27.3	10.1
Apple Manual	9.1	0.9	34.5	55.5
MECC courseware	32.0	5.0	38.0	25.0
Courseware demonstration	30.7	5.0	41.6	22.8
Courseware Development Fund	81.9	2.1	7.4	8.5
Local District Personnel	13.8	3.7	35.8	46.8
JEM Research Team/ Ministry personnel	58.6	4.0	32.3	5.1
Other Organizations or associations (please specify)	83.1		6.8	10.2
University-based workshops	58.9	1.1	24.4	15.6
District-based workshop	33.3	4.0	37.4	25.3
Other (please specify)	64.0		4.0	32.0

Subjective Findings

Opinions

Recommended Use

Consistent with how the microcomputers were used in the pilot study are the opinions of respondents relative to the microcomputers desired utility.

As discussed earlier in this report, all of the coordinators and the majority of the teachers ranked CAI as the most important use of the microcomputer, with courseware development ranking second in importance followed by teacher training and administrative record keeping (Table 10). Although teachers felt that courseware development was an important use of the microcomputer, in actual fact, it was used only 17% of the time for this purpose.

Half the teachers felt that the best location for the microcomputer was in the regular classroom while 36% felt that they should be placed in a computer lab (Table 11).

A majority of the coordinators and teachers recommended that microcomputers be introduced at the primary level. None felt that they should be introduced at the senior secondary level although some senior secondary teachers felt that microcomputers should enter the school system at the junior secondary level (Figures 9 & 10).

Approximately 50% of the teachers indicated that they preferred that the microcomputer be introduced into the school system as quickly as possible (Figure 1). Thirty-seven percent wanted to see a gradual introduction of the technology, and 15% indicated that they wanted to see more thought given to the question.

The coordinators were more cautious. Seven of the 12 indicated that they thought microcomputers should be introduced into the schools gradually (Figure 12).

Unsolicited comments on this item of the questionnaire repeatedly emphasized that the respondents wanted to see microcomputers introduced into the schools, but only if supported and accompanied by solid, continuous pre-and in-service training.

The teachers were evenly split in their opinion as to whether the microcomputer provided instruction that was less effective than, as effective as, or better than traditional instruction (Figure 13). The cautious acknowledgement by the majority of the teachers that they felt that using the microcomputer provided instruction that was as good as or better than traditional instruction is consistent with the literature which generally agrees that in some learning situations, instruction with the computer is more effective than with traditional instruction (Figure 14).

Almost all of the coordinators and all of the teachers judged student motivation to be as good as or better with the microcomputer than with traditional instruction. Over 90% felt that student achievement was as good as or better. They appeared to have mixed feelings about the microcomputer's cost-effectiveness (57), but the majority were of the opinion that the microcomputer was less effective in the type of course offered (Table 12).

All of the coordinators and 92.5% of the teachers believed that the quality of instruction was enhanced by the use of the microcomputers; all of the coordinators and 94.1% of the teachers felt that the quality of student learning was similarly enhanced.

From the information included in subjective comments on the effectiveness items of the questionnaire, it appears that teachers felt that the motivation provided by the colour and the visual displays; the involvement encouraged by the interactive capabilities of the microcomputer; the immediate corrective feedback; the branching capabilities; the ability to provide for different levels and paces of instruction; and the carefully sequenced instructional design were some of the features identified by teachers as enhancing instruction. They indicated that the microcomputer, while demanding a high degree of concentration, challenged and motivated students at all levels of interest and ability. One teacher pointed out that using the computer gave students a new area to feel confident about while others indicated that it had freed them from mundane and time-consuming tasks. A number of teachers pointed out that the microcomputer was obviously effective in teaching such courses as computer science.

However, a number of teachers gave reasons why they felt that the microcomputer was less effective than traditional instruction. They mentioned that young students cannot be relied upon to work independently with the microcomputer; that the all important give and take between the teacher and student in question and answer sessions is lost; that most of the courseware that they attempted to use was of an unacceptable quality; that programs were too inflexible in design; and that using the microcomputer took more time and trouble than it was worth.

On this item, teachers over and over again emphasized that the microcomputer was at its best when used as an aid to instruction and not as a substitute to traditional instruction.

The majority of senior secondary teachers reported courses which used the microcomputer to be as good as or better than traditional methods, probably reflecting the microcomputer's use at this level as an aid in the teaching of computer science, text editing, data processing, and in science labs where the microcomputer was used to provide demonstrations and simulations. There was less satisfaction for intermediate and junior secondary than for primary teachers who, perhaps, had fewer expectations both for the microcomputer and for the students' use of it.

All of the coordinators and the majority of the teachers felt that students were either enthusiastic or highly enthusiastic in their support for microcomputer instruction and use (Figures 15 & 16). Similarly, all of the coordinators and 95.6% of the teachers indicated that they were either interested or very interested in continued involvement with the use of microcomputers for instructional purposes (Figures 17 & 18). Both coordinators and teachers agreed that in the majority of cases, parents were either enthusiastic or very enthusiastic toward microcomputers in the schools (Figures 18 & 19).

In summary, it was recommended by the participating teachers and coordinators that the microcomputer be introduced into the school system at all levels to enhance and support traditional instruction where appropriate and cost effective, and that the introduction of the microcomputers be accompanied by solid in-service and field support.

TABLE 10

AVERAGE RANK OF IMPORTANCE

A number 1 indicated the most important, number 4 least important. The first column represents the average teacher ranking, the second the average coordinator ranking.

	Primary		Inter- mediate		Jr.Sec.		Sr.Sec.	
Admin. Record Keeping	3.1	3.5	2.9	3.4	2.6	3.2	2.4	3.0
CAL	2.0	1.0	1.5	1.0	1.8	1.0	1.8	1.0
Teacher Training	2.8	2.7	2.7	2.8	2.5	3.0	2.7	3.2
Courseware Development	3.0	3.1	2.7	3.1	2.4	2.7	2.1	2.6

TABLE 11

BEST LOCATION FOR MICROCOMPUTERS

	% of teachers
Regular classroom	52.8
Special computer lab.	36.8
Library	4.7
Resource Center	4.7
Other	6.9

LEVEL MICROCOMPUTERS SHOULD BE INTRODUCED
FIGURE 9

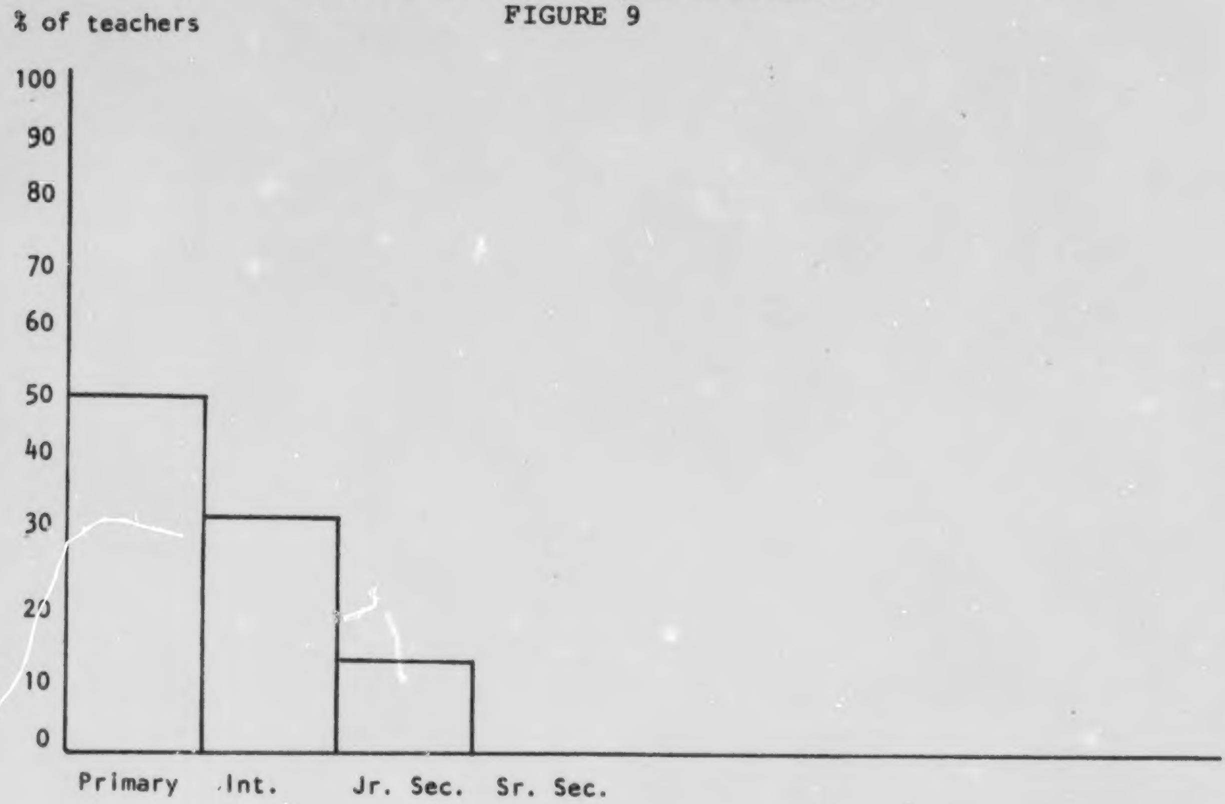
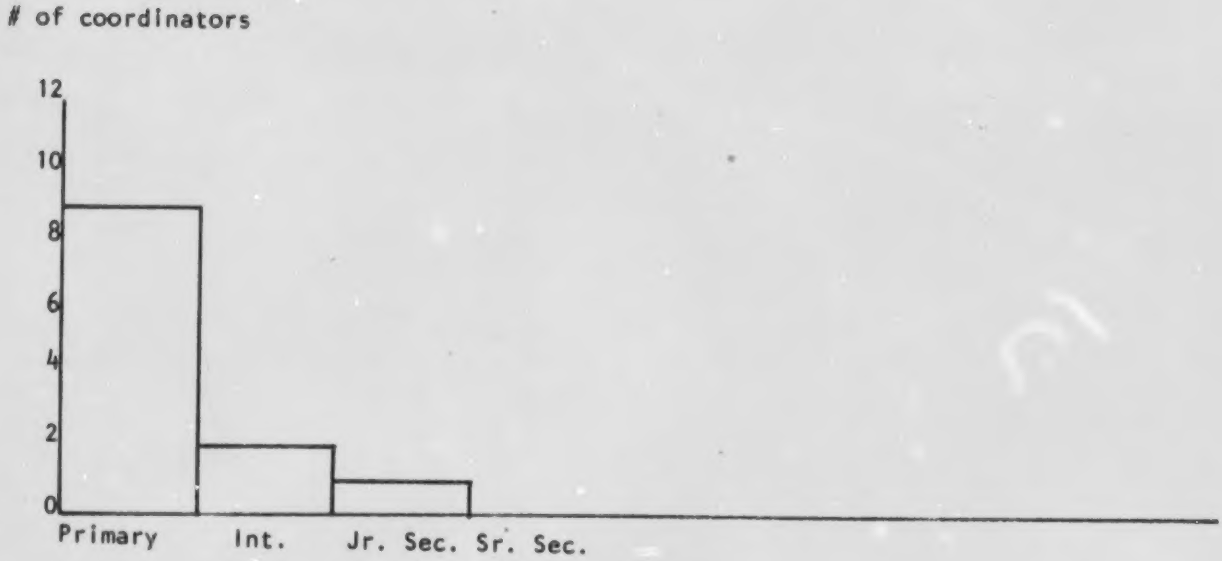


FIGURE 10



RATE MICROCOMPUTERS SHOULD BE INTRODUCED

FIGURE 11

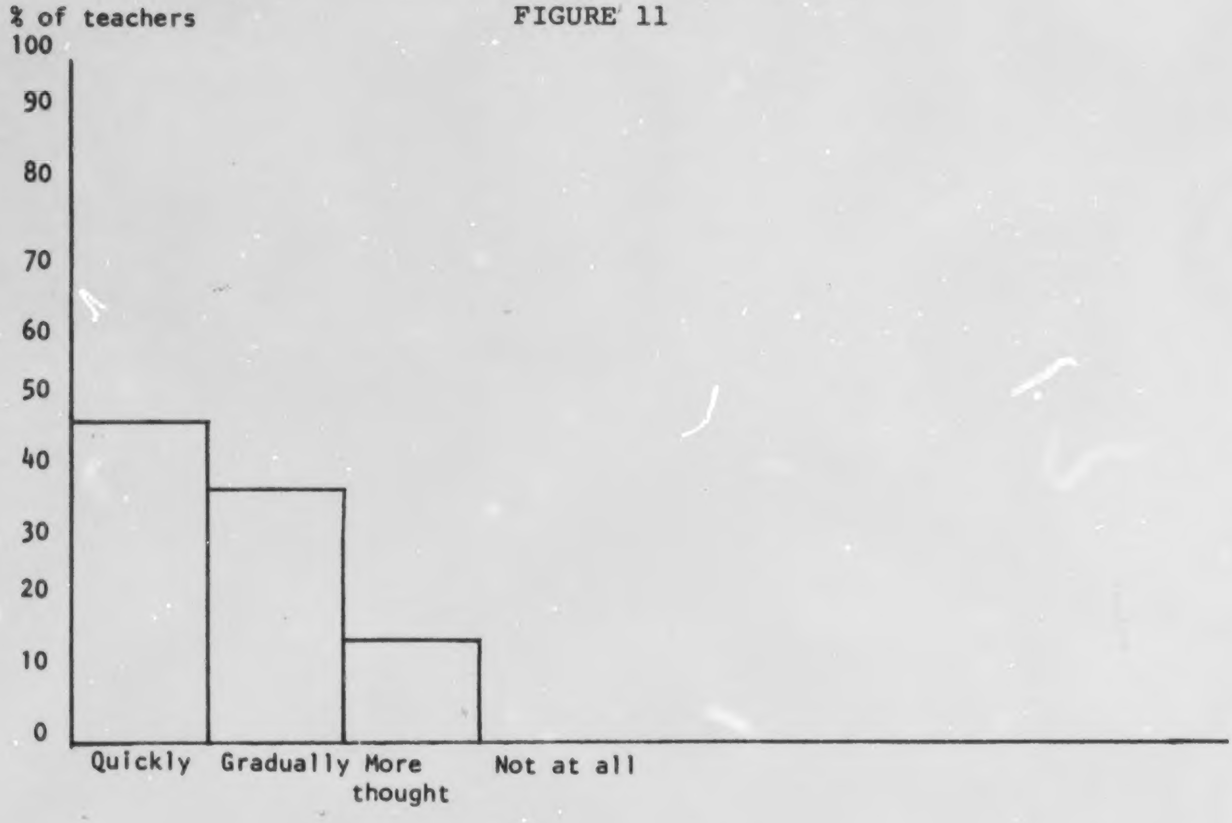
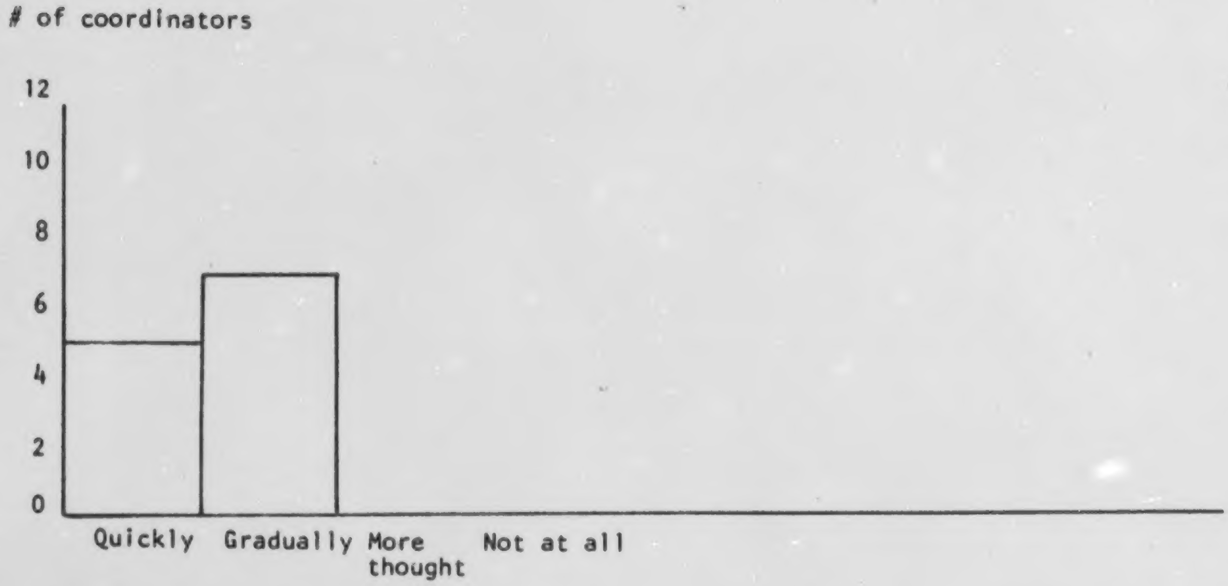


FIGURE 12



MICROCOMPUTER VS. TRADITIONAL INSTRUCTION

FIGURE 13

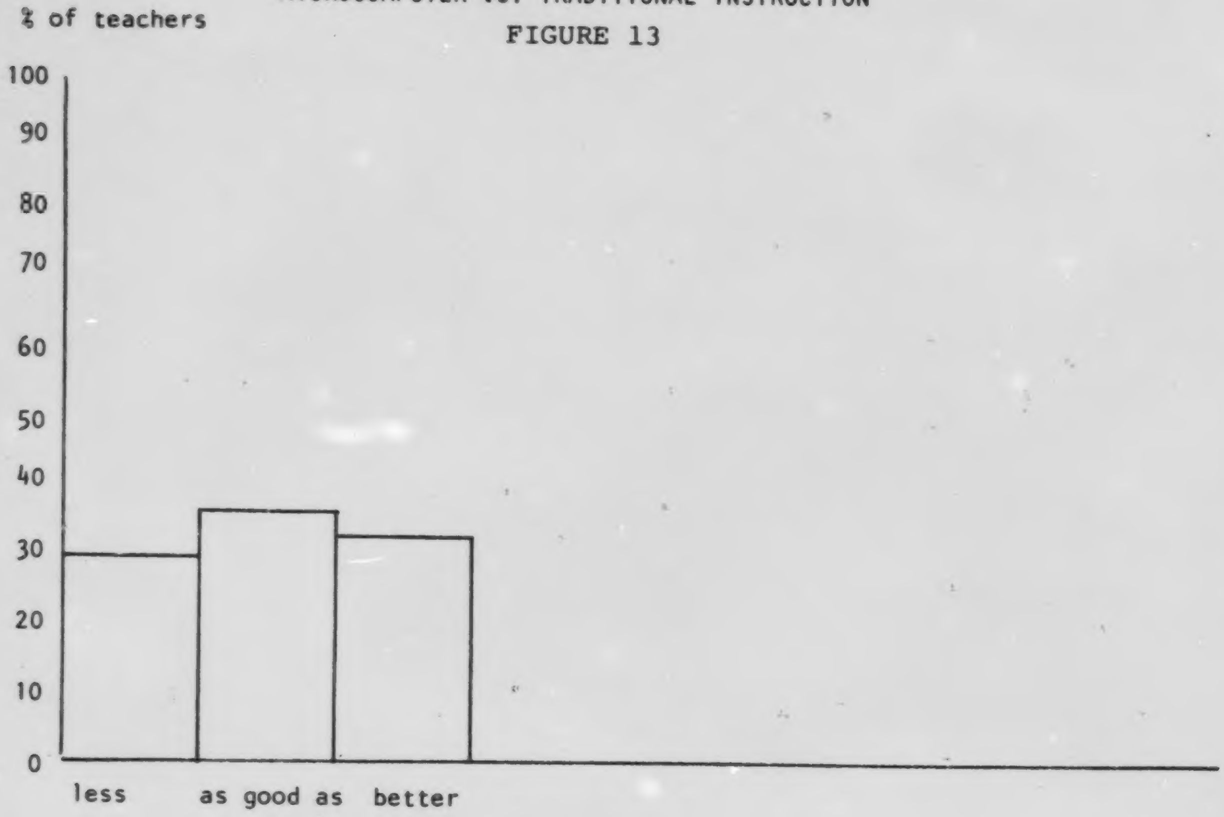


FIGURE 14

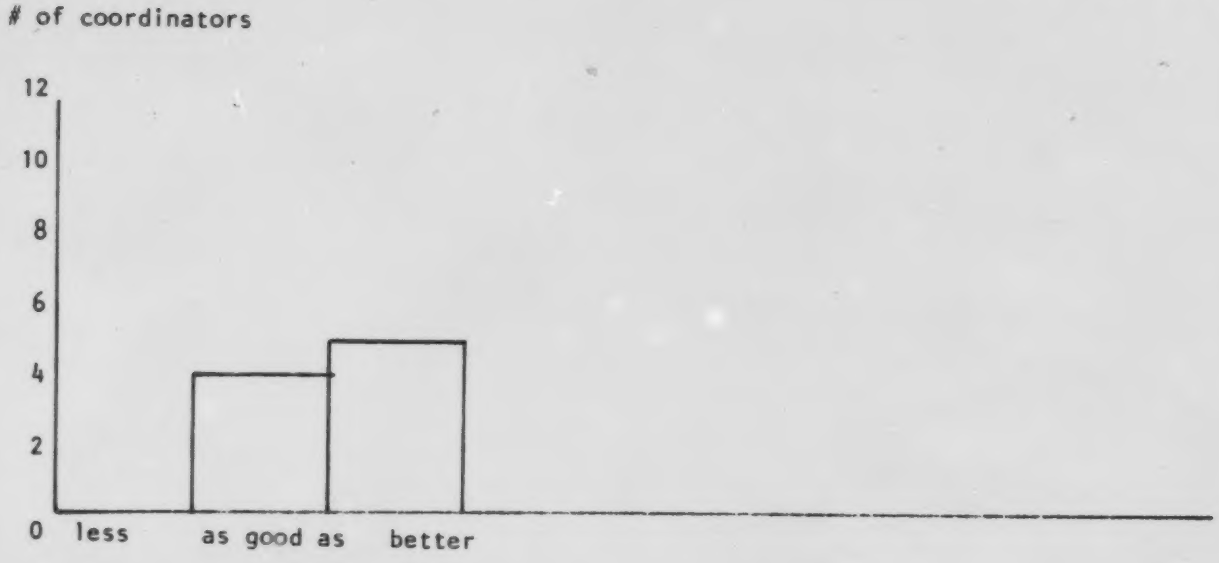


TABLE 12

INSTRUCTIONAL USE OF MICROCOMPUTERS VS. TRADITIONAL INSTRUCTION

The first column represents the % of teachers; the second the number of coordinators.

	Less effective		As good		Better	
Cost effectiveness	45.6%	3	35.6%	5	18.9%	0
Student motivation	1.9%	0	27.1%	0	71.0%	8
Ease of use	24.0%	2	51.0%	5	25.0%	0
Student achievement	8.4%	0	58.9%	4	32.6%	4
Type of courses offered	58.5%	1	26.6%	3	14.9%	4

PERCEPTIONS OF STUDENT'S ATTITUDES

FIGURE 15

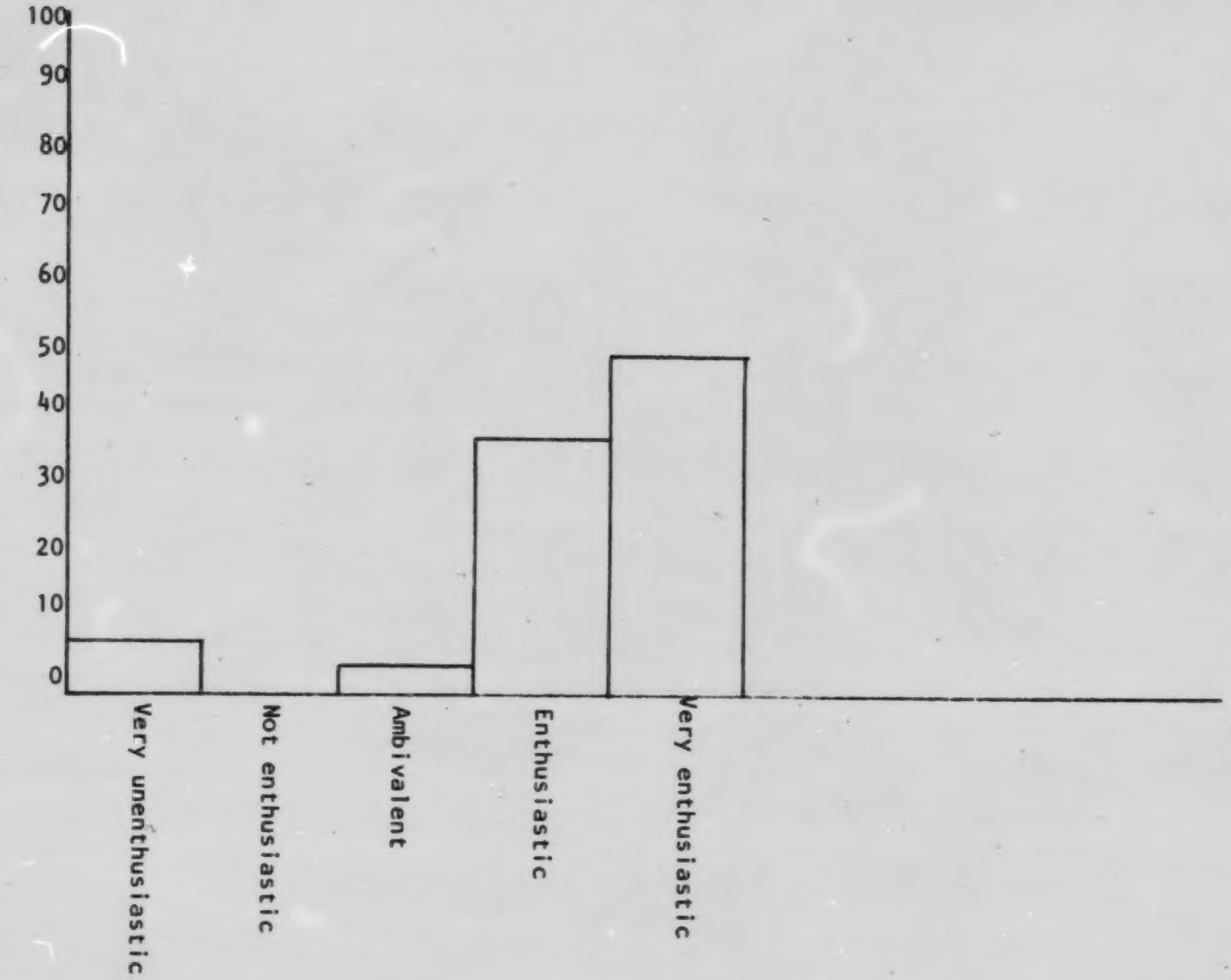
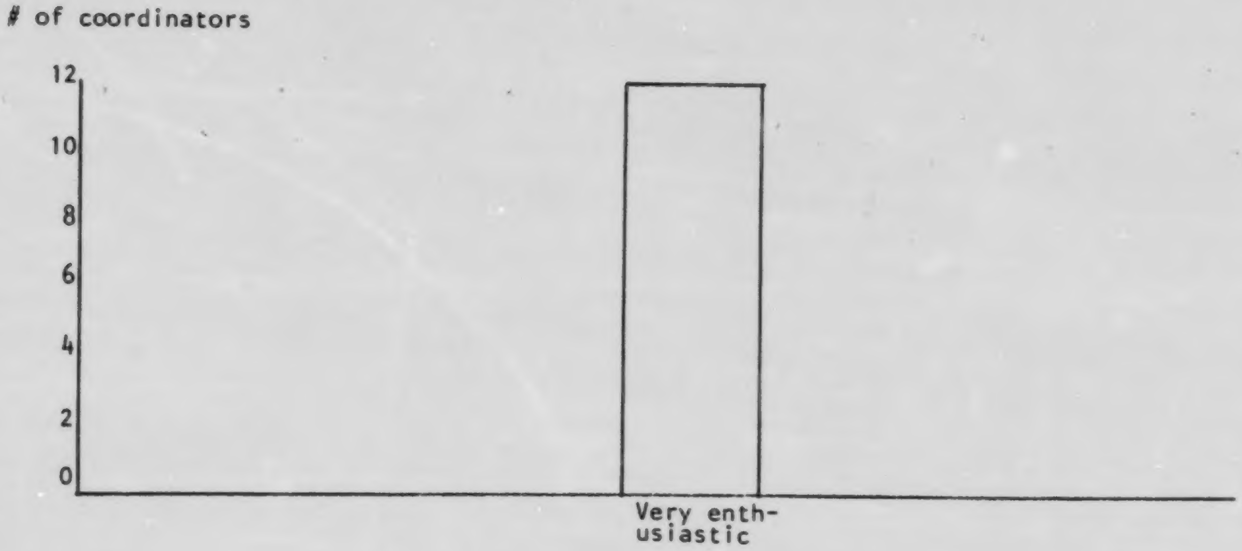


FIGURE 16



OWN INTEREST IN CONTINUED INVOLVEMENT WITH MICROCOMPUTERS

FIGURE 17

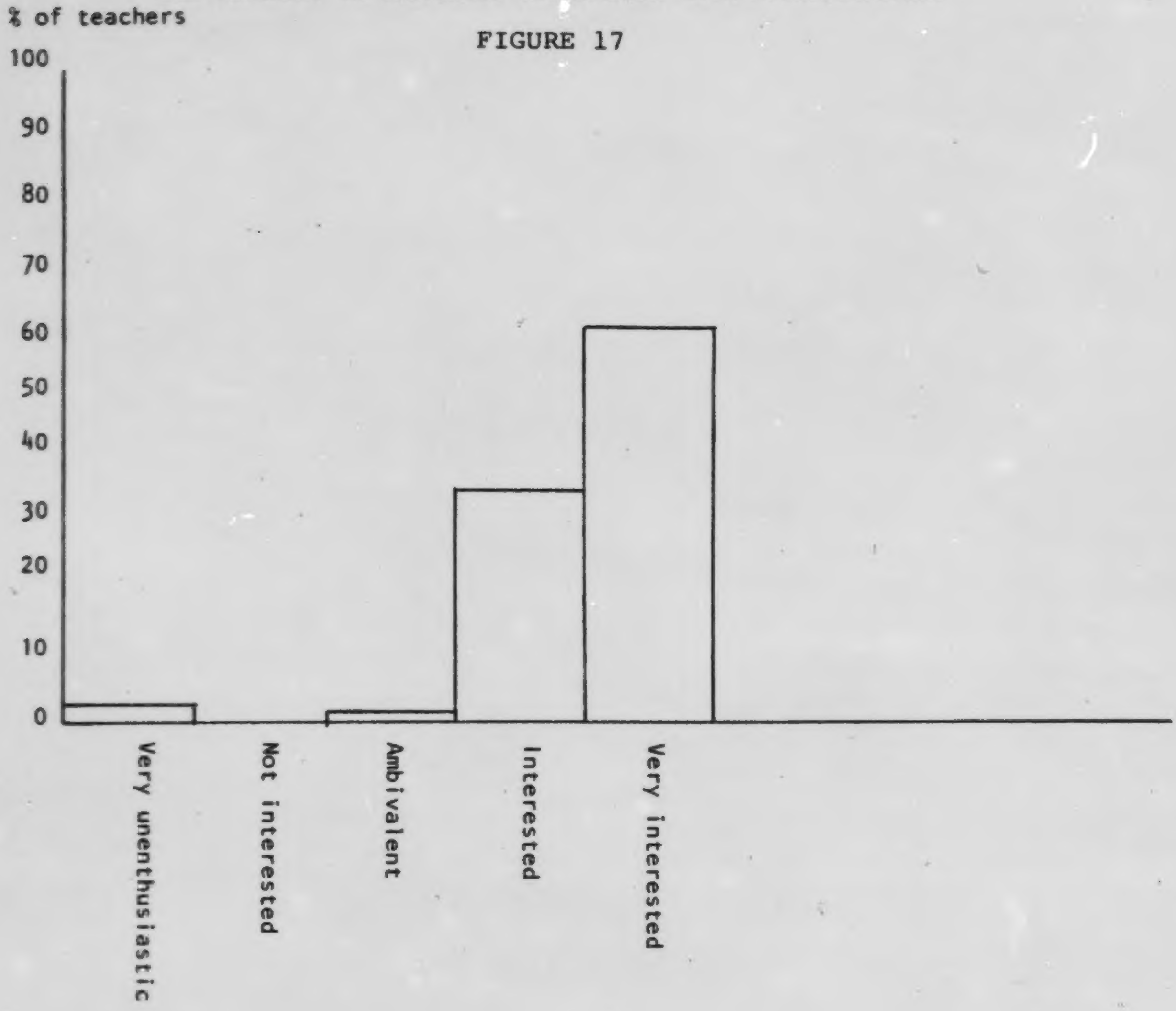
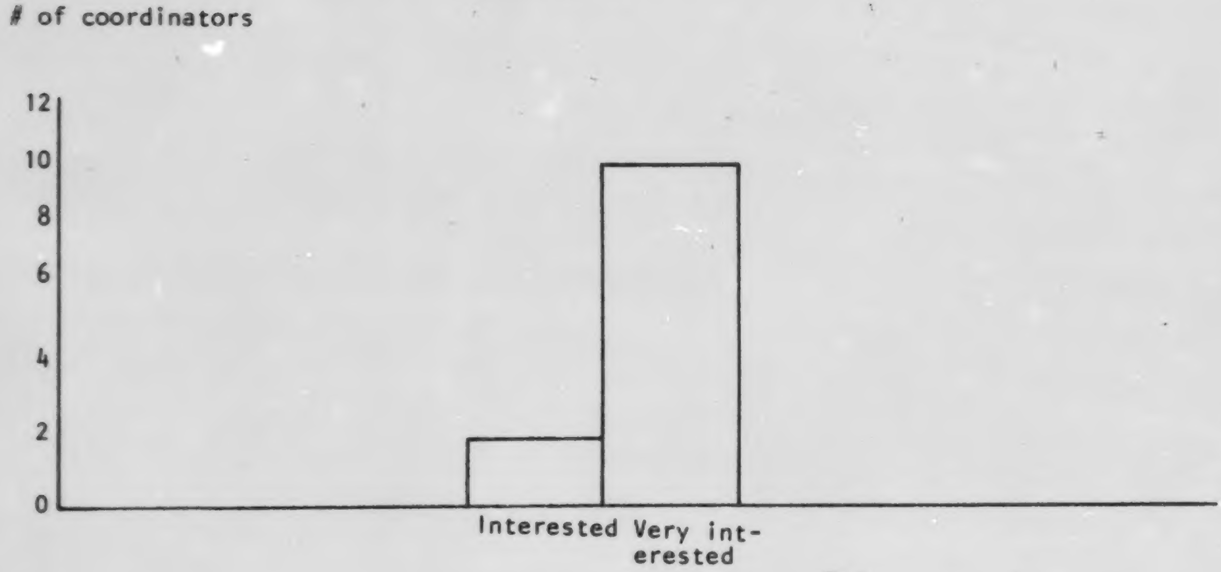


FIGURE 18



PERCEPTIONS OF PARENT'S ATTITUDES

FIGURE 18

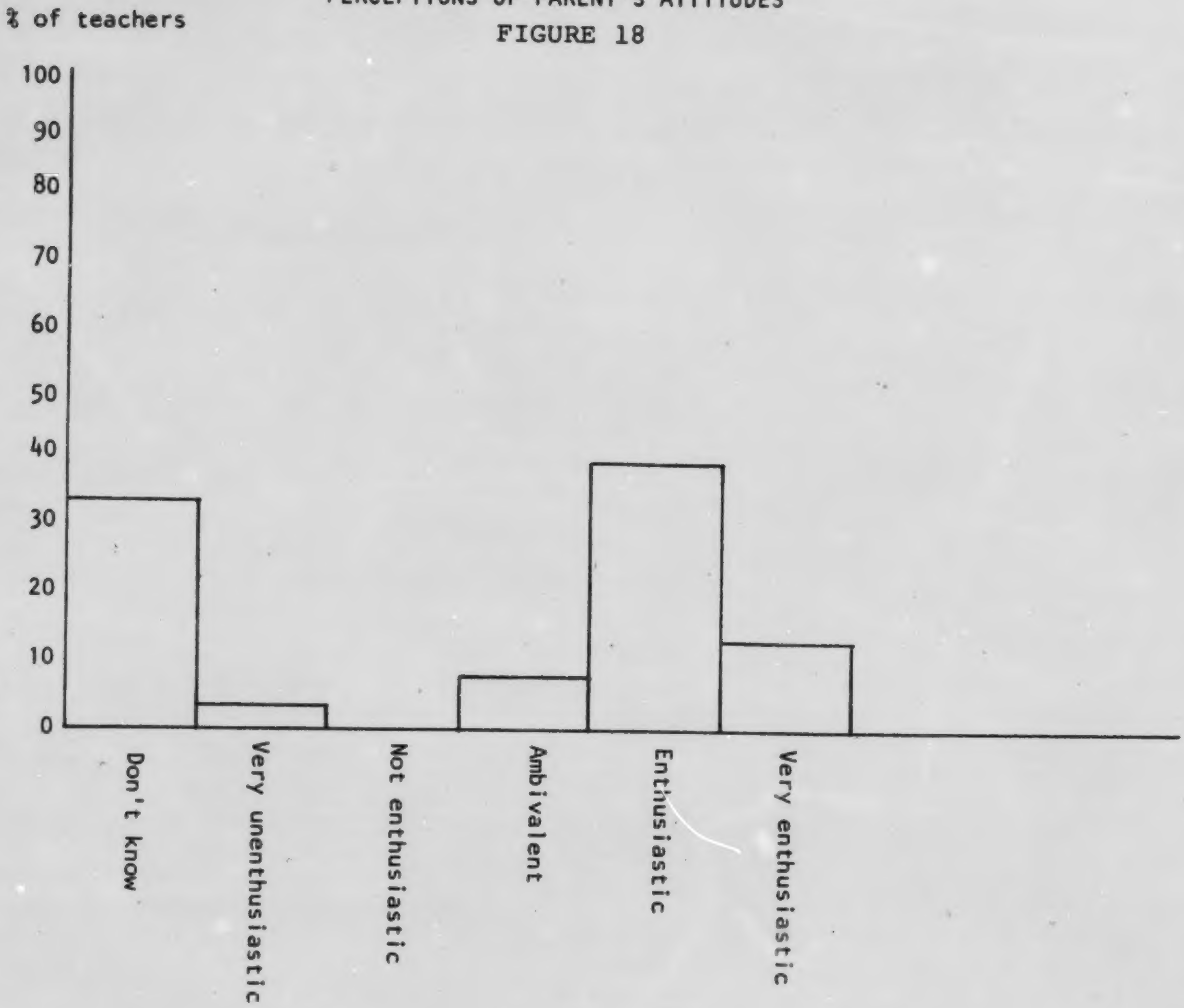
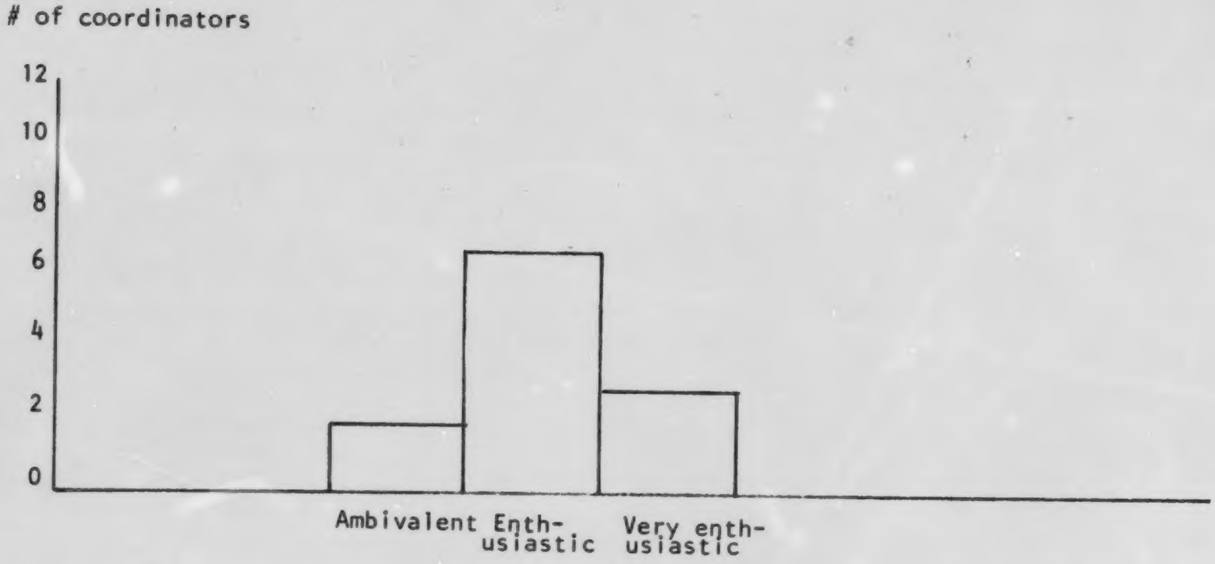


FIGURE 19



Subjective Findings

Opinions

Perceived Needs

All of the coordinators and 72.4% of the pilot teachers felt satisfied or very satisfied with the pilot project (Figures 20 & 21). Nine of the 12 coordinators felt that they had met their original objectives for the project, but 57.9% of the teachers believed that they had met their objectives only to a limited extent, and only a third of them felt that they had "mostly" met their objectives (Figures 22 & 23). Although districts were generally encouraged to comply with their original proposal objectives, half of the teachers and half of the coordinators indicated that their original objectives had changed (Figures 24 & 25). However, only half of the teachers and 4 of the 12 coordinators felt that they had been able to meet their new objectives (Figures 26 & 27), suggesting that unrealistic original objectives were only part of the reason for whatever dissatisfaction was felt.

Approximately half of the participating teachers and 8 of the 12 coordinators identified the limited availability of microcomputers as an impediment to their reaching their objectives. The lack of availability of microcomputers obviously is a matter that can only be addressed by funding either at the district or Ministry level, but it is interesting to note that contrary to fears that the microcomputer will go the way of educational television, it appears that there was too heavy a demand for the machines that were available.

The second major impediment identified by 9 of the coordinators and 47.3% of the teachers was the lack of courseware. Teachers were not asked to indicate whether this was from a lack of funding to purchase courseware or from a lack of good, relevant courseware to purchase, but interviews with teachers and coordinators for the formative evaluation indicated that both funding and good courseware were lacking.

The evidence that approximately 60% of the teachers and 8 of the 12 coordinators felt that their pre- and in-service training had been inadequate or only partially adequate suggests another of the reasons for the dissatisfaction that approximately 30% of the teachers and 3 of the 12 coordinators felt with the project. Subjective comments by teachers indicated that many had begun the project with unrealistic objectives based on their lack of knowledge and understanding about the capabilities and limitations of the microcomputer. One third of the teachers had had no previous experience with computers, and 42% indicated that inadequate preparation contributed to the difficulties they felt in reaching their objectives (Table 13). A quarter of them also cited insufficient in-service opportunities as a contributing factor.

Only 2 of the 12 coordinators, however, felt that lack of preparedness was a factor although the majority did feel that there had been inadequate pre- and in-service training. The coordinators, although recognizing the need for training, had judged themselves to be fairly computer literate and this may account for their not identifying preparedness as a factor in their not having reached their original objectives.

Because of the arrangements with the central hardware purchaser, pilot districts were obliged to send their microcomputers to Victoria for service and maintenance. One quarter of the teachers and one third of the coordinators felt that this had been a problem and in their interview and questionnaire comments, they suggested that in future, servicing should be arranged locally or microcomputers with service contracts should be purchased locally to avoid this problem. Generally, it was agreed, however, that the Apple II had been very serviceable and trouble free.

When asked to give an opinion as to which inservice components should be emphasized to assure the effective integration of microcomputer technology into the schools, both coordinators and teachers felt that the major emphasis should be on using teacher aids, learning integer and applesoft BASIC, and reviewing and running commercially available materials. They also indicated that they felt there should be some emphasis on computer care and maintenance, interfacing the microcomputer to video, and using authoring languages (Table 14). A number of teachers indicated on their questionnaire forms that they thought it was essential that in-service training provide assistance to teachers in strategies for integrating the computer into the regular classroom and incorporating CAI programs into the lesson plan and the established curriculum. It was also pointed out that the list of choices should have included programming in machine language and information on operating systems.

The coordinators and teachers' personal preferences for in-service topics reflected their own level of computer literacy and the emphasis they placed on in-service topics as described above.

Both teachers and coordinators expressed a personal interest in pursuing further training in authoring languages although neither of them indicated in the previous item that they thought that this topic should receive much emphasis. The coordinators expressed less interest than the teachers in teacher aids and integer and applesoft BASIC, but expressed more interest in authoring languages, Pascal, and computer care and maintenance (Table 15).

It is interesting to note that teachers' requests for future in-service represent the needs of a teacher population that has had a good introduction to using the microcomputer and is now ready to move on to more challenging activities and topics. For example, 40% of the teachers did not want to spend time learning how to assemble the components of a microcomputer system, but almost 100% of them indicated that they wanted to learn authoring and programming languages. Similarly, the coordinators, already judged to be at least reasonably literate, indicated an interest in such 'future' topics as interfacing the microcomputer to the videotape player and learning Pascal.

Both coordinators and teachers preferred the in-service format of either occasional one day workshops or a regular program throughout the year. The teachers also felt that it was important to have access to an experienced consultant as needed (Table 16). Teachers commented, both in the formative and the summative evaluation, that it was unreasonable for the schools to expect teachers to become computer literate on their own time and they emphasized the need for release time and financial assistance for teachers to attend evening and summer school courses and to assist their less computer literate colleagues. As one teacher put it, with his knowledge of computers, he was a "hot item".

OVERALL SATISFACTION WITH PILOT PROJECT

FIGURE 20

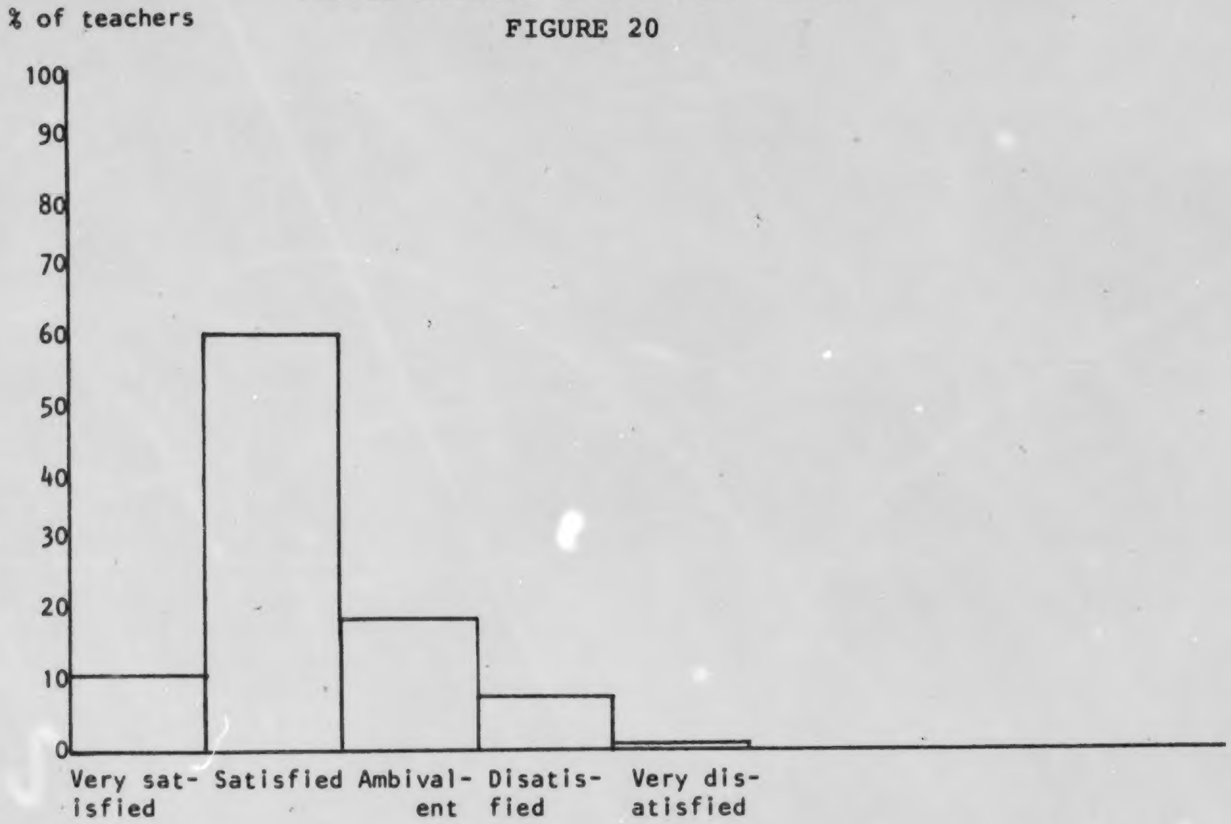
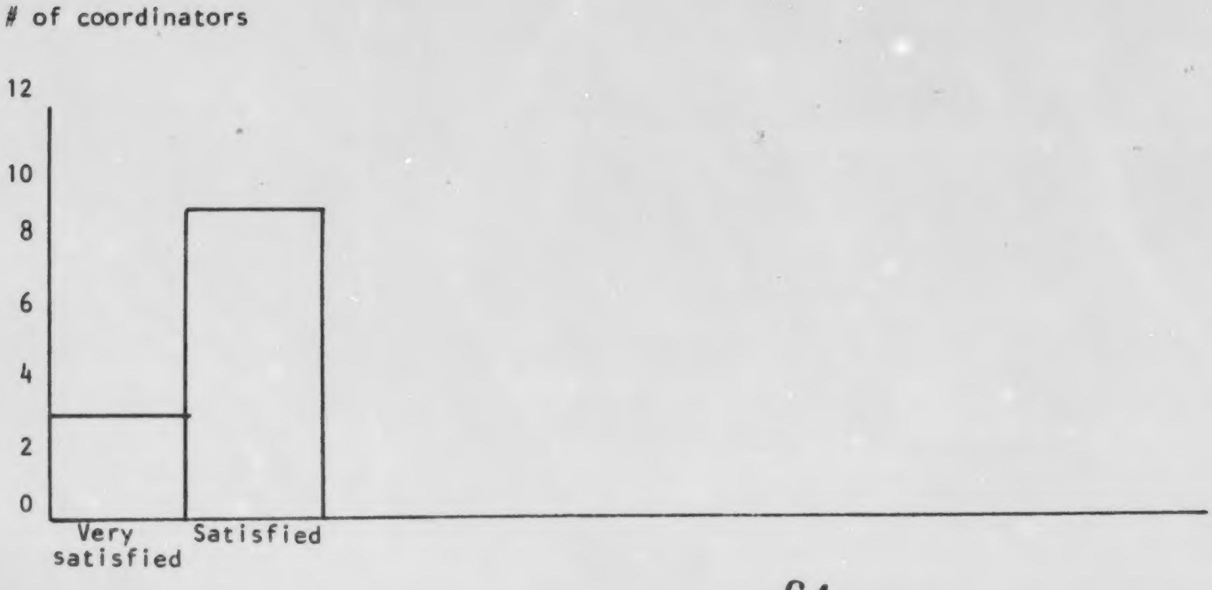


FIGURE 21



DEGREE TO WHICH OBJECTIVES WERE MET

FIGURE 22

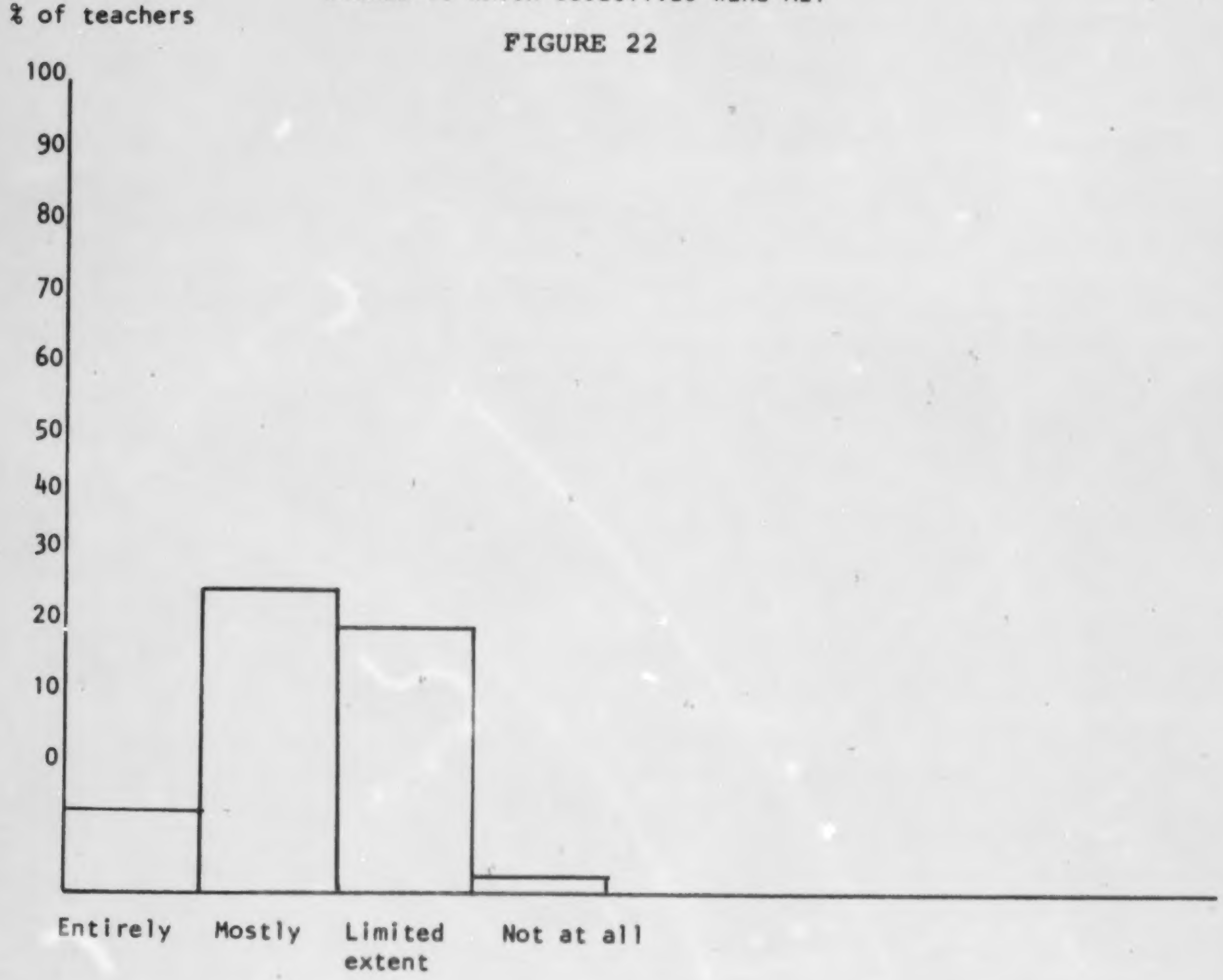


FIGURE 23

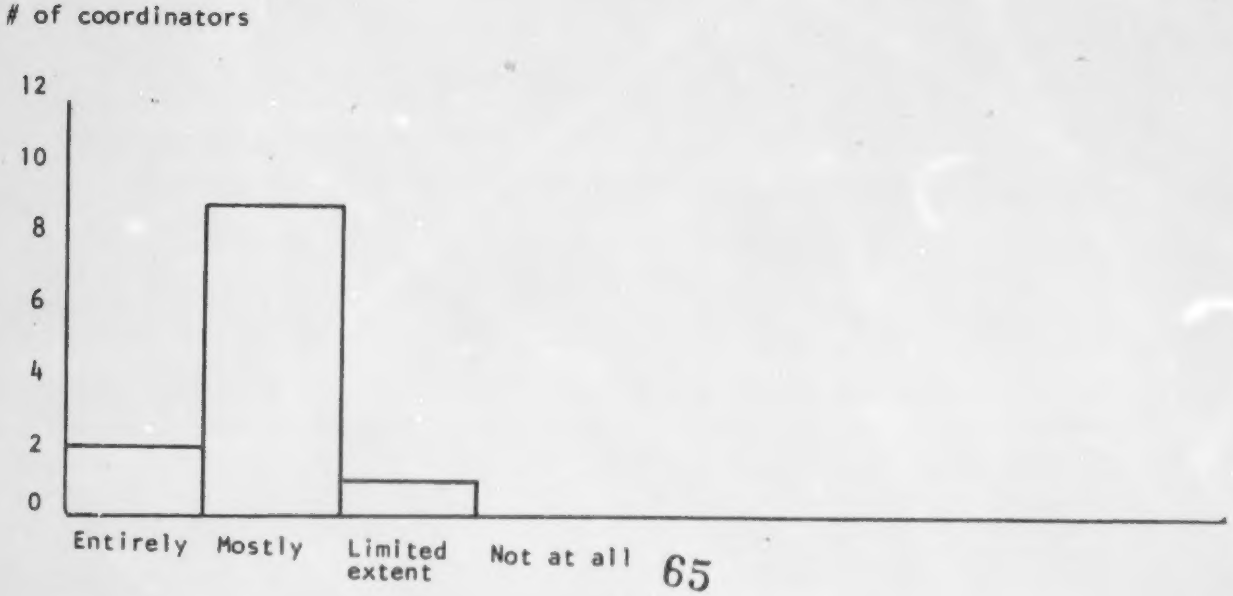


TABLE 13

IMPEDIMENTS TO MEETING INITIAL OBJECTIVES

	% of teachers	# of coordinators
Completely Satisfied	6.3	1
Original scope unrealistic	10.7	4
Inadequately prepared	42.0	2
Limited availability of microcomputers	57.1	8
Problems with servicing and maintenance	24.1	4
Lack of peripherals and software	43.8	2
Inadequate courseware	47.3	9
Poor district coordination	8.0	0
Poor Ministry coordination	8.0	0
Insufficient in-service opportunities	24.1	4
Lack of district support	10.7	2
Others	17.0	2

INITIAL OBJECTIVES CHANGED

FIGURE 24

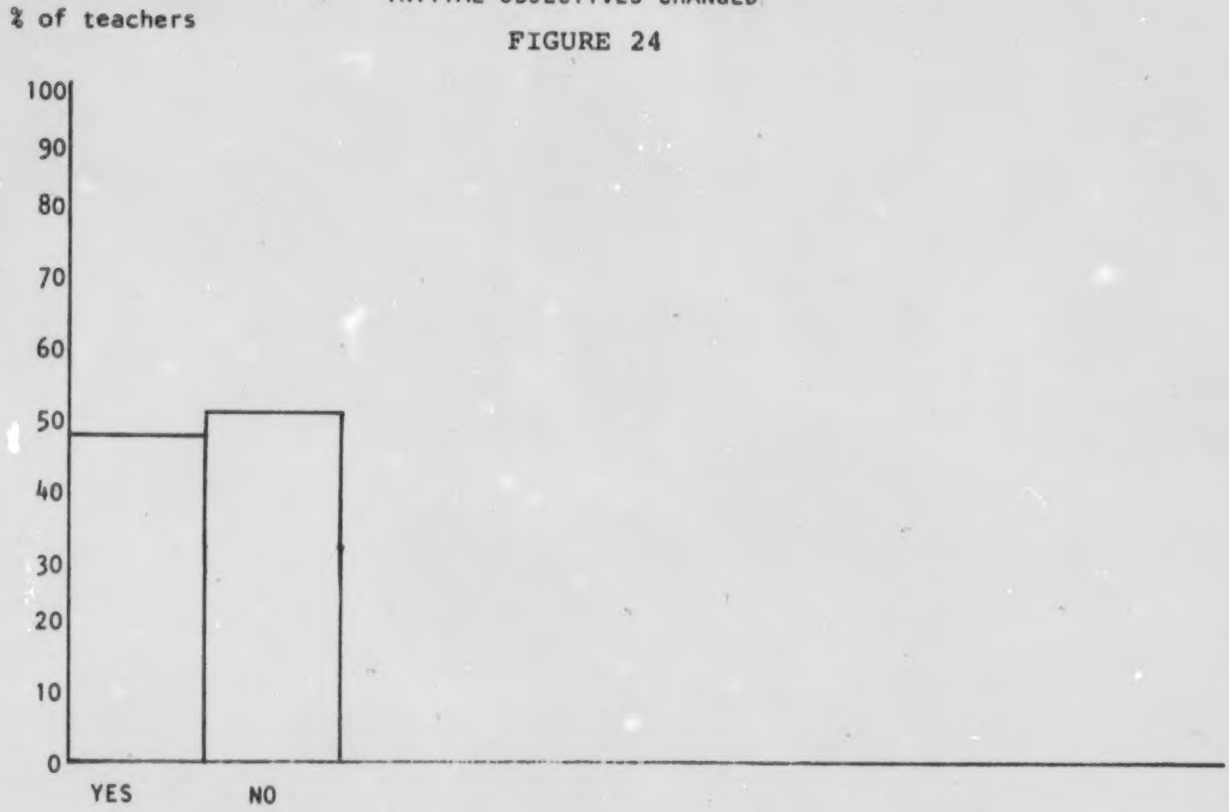
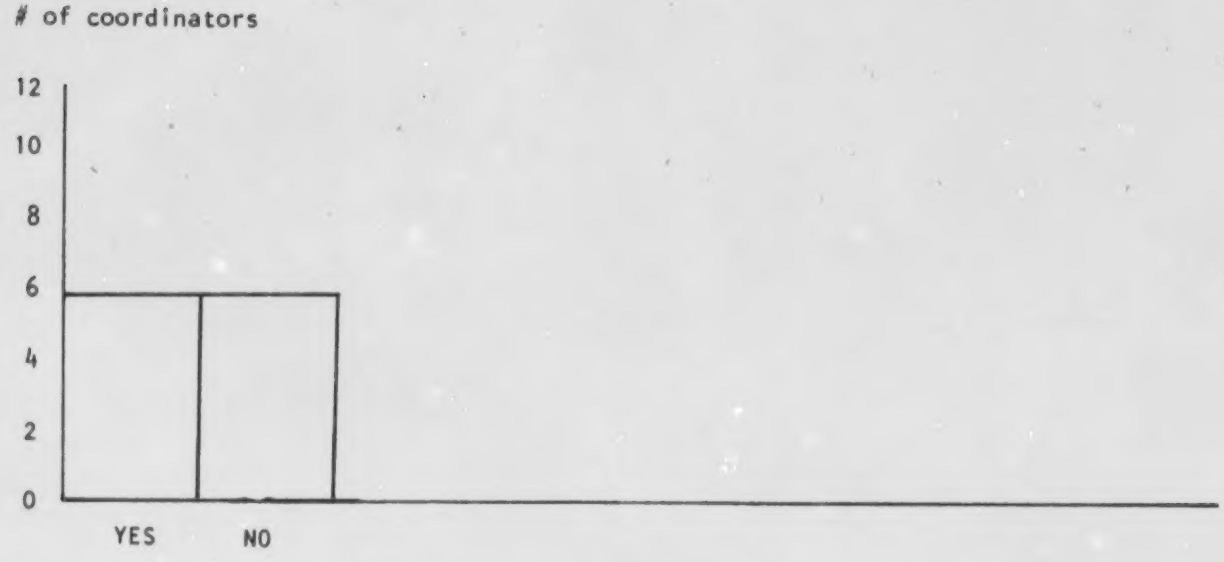


FIGURE 25



NEW OBJECTIVES MET

FIGURE 26

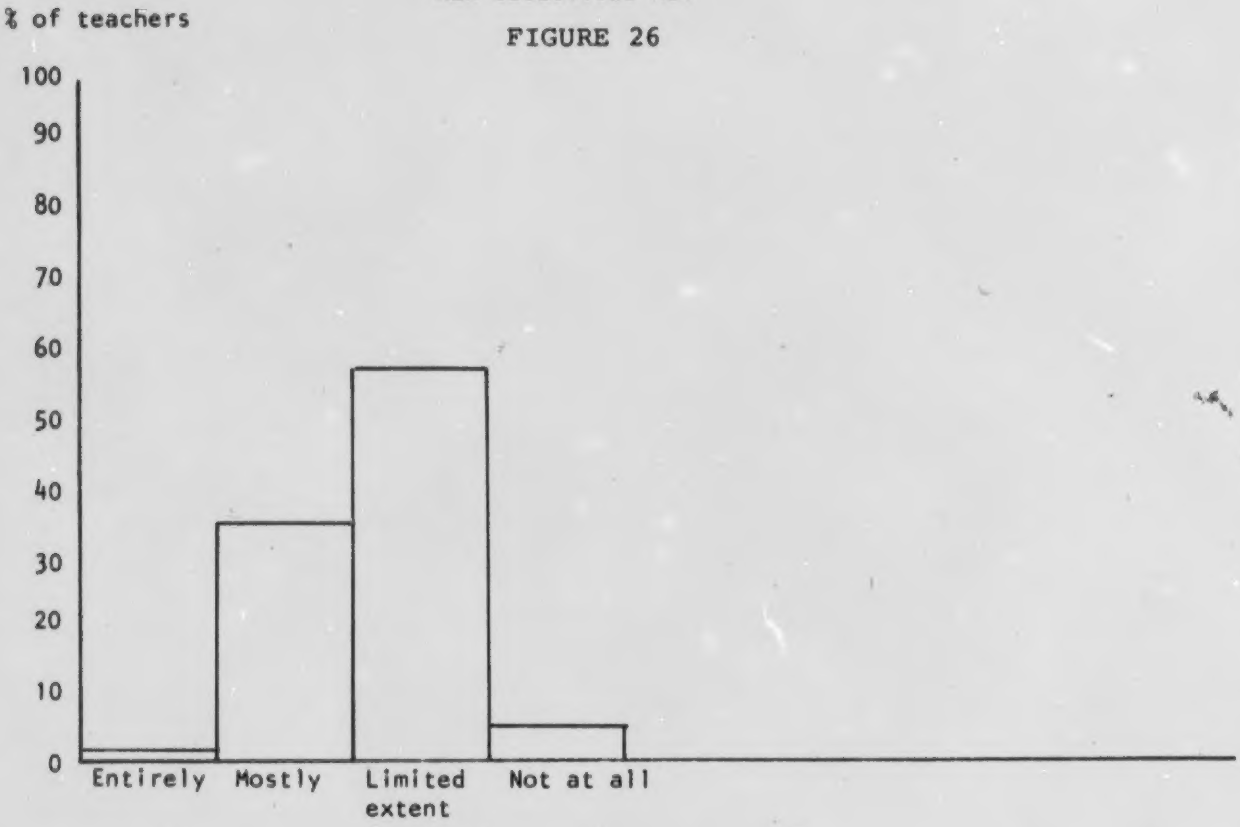


FIGURE 27

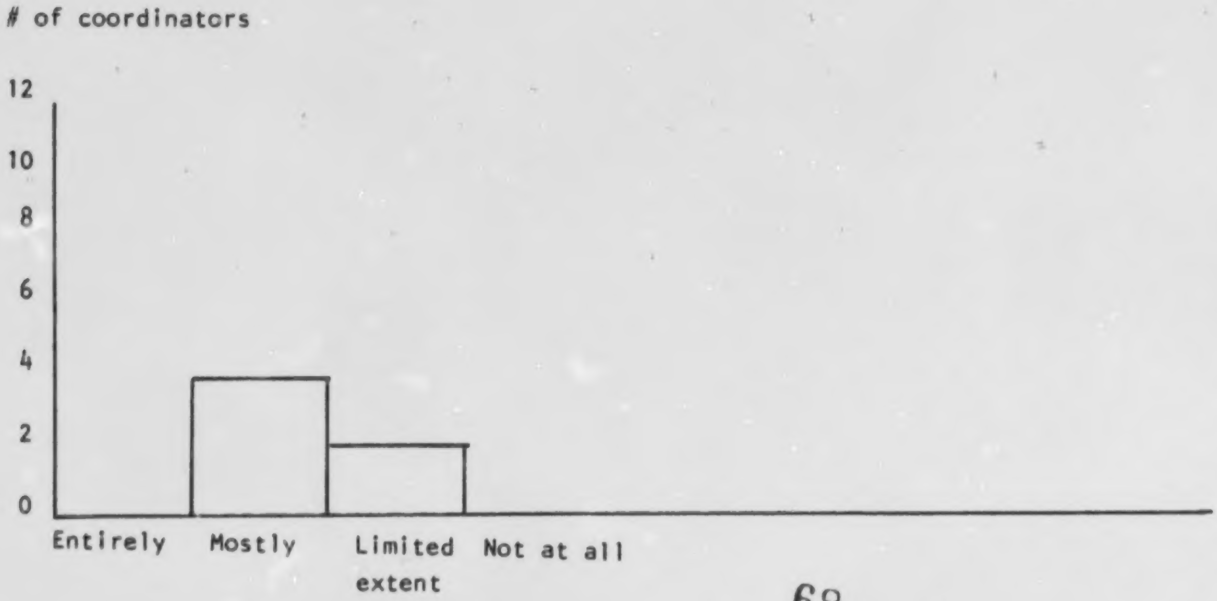


TABLE 14

DEGREE TO WHICH IN-SERVICE COMPONENTS SHOULD BE EMPHASIZED

The first column represents the % of teachers, the second the number of coordinators.

	No emphasis		Little emphasis		Some emphasis		Much emphasis	
Assembling the Apple System	3.7	1	42.2	4	43.1	4	11.0	3
Running commercial materials	0.9	1	12.5	2	42.9	5	43.8	4
Reviewing commercial materials	0.9	1	8.8	1	45.1	4	45.1	6
Using teacher aids	1.8	2	5.4	0	45.0	6	47.7	4
Using authoring languages	3.9	1	18.6	4	47.1	5	30.0	2
Learning integer and Applesoft BASIC	4.5	1	11.7	2	37.8	4	45.9	5
Pascal	22.6	2	35.7	5	27.4	4	14.3	1
Interfacing Apple with Video	2.2	1	30.8	4	49.5	5	17.6	1
Computer care and maintenance	3.6	1	11.8	1	59.1	9	25.5	1
Other	-	8	-	-	-	-	-	1

TABLE 15

IN-SERVICE PREFERENCES

The first column represents the % of teachers, the second the number of coordinators.

	No emphasis		Little emphasis		Some emphasis		Much emphasis	
Assembling the Apple System	34.9	7	25.3	1	28.9	2	10.8	2
Running commercial materials	12.6	5	14.9	1	43.7	3	28.7	3
Reviewing commercial materials	4.3	2	7.5	2	50.5	3	37.6	5
Using teacher aids	8.9	5	7.8	1	36.7	3	46.7	3
Using authoring languages	7.5	3	12.9	-	32.3	3	47.3	6
Learning integer and Applesoft BASIC	9.4	4	10.4	3	27.1	2	53.1	3
Pascal	23.6	4	15.3	1	27.8	2	33.3	5
Interfacing Apple with Video	14.3	3	19.0	1	40.5	5	26.2	3
Computer care and maintenance	11.0	3	23.1	0	45.1	4	20.9	5
Other	-	9	-	-	-	-	-	-

TABLE 16

DESIRED IN-SERVICE FORMAT

	% of teachers	# of coordinators
Series of after school workshops	12.6	-
Occasional one day workshops	25.3	1
University/College summer course for credit	5.7	-
One week summer workshop	11.5	1
Regular program throughout school year	20.7	5
Access to consultant	21.8	2
Other	2.3	-

Conclusions and Recommendations

The purpose of The Instructional Uses of Microcomputers Project was to gather information regarding the use of the microcomputer within the school system of British Columbia. It was to be an exploratory project which would rely on the creativity and the involvement of the teachers and the administrators in the participating school districts.

Recognizing the need to allow freedom for teachers to develop their expertise, to gain experience, and to experiment in a classroom setting, and taking into consideration the limitations in available resources, the project was designed for flexibility. The questions raised at the beginning of the project were deliberately general ones and were designed to gather information rather than to provide definite answers.

The project provided very useful information on the province's actual and recommended use of the microcomputer in an instructional setting. The experiences and opinions of the teachers and administrators in the province of B.C. appear to be generally consistent with what is reported in a search of the literature which has been included following this section of the report.

The majority of the teachers across all grade levels felt that instruction with the microcomputer was as effective or more effective than traditional instruction in certain learning situations. They cited increased motivation and achievement gains as what they felt to be the major reasons for the enhancement of the learning situation through the use of the microcomputer. The majority of the teachers were also of the opinion that students' attitudes toward learning was improved as they were very enthusiastic about the opportunity to use the microcomputer for instruction.

When asked whether they believed the microcomputer was a cost effective method of instruction, few teachers were prepared to give an opinion but of those who did, a small majority felt it was less cost effective than traditional instruction. A search of the literature indicates that researchers have been unable to answer this question satisfactorily.

The participating teachers agreed with the literature that the computer's advantages include its ability to individualize the instructional process; to simulate experiences not possible without a computer; to provide immediate reinforcement and corrective feedback; to motivate students; to provide carefully sequenced instruction; and to provide courses that would not have been possible without the use of the computer.

Although the teachers indicated in the formative evaluation that computer literacy was a major focus in their microcomputer projects, the summative evaluation questionnaire neglected to include this focus as a potential use of the microcomputer. It was therefore not possible to determine to what extent the teachers in the province felt that computer literacy was a rationale for supporting the introduction of microcomputers into the school system of the province. However, the formative evaluation and subjective comments provided by the teachers and coordinators indicated that they believed that computer literacy should be a major goal for the students and teachers in the province. This is consistent with the opinion of educators reviewed in the search of the literature.

The impediments to implementaion identified by the participants in the project are, for the most part, consistent with those identified in the literature. Researchers have identified insufficient funding to purchase hardware and courseware, the diversity of languages and hardware systems, poor quality and insufficient quantity of courseware, lack of knowledge among teachers, and a poor attitude among teachers as impediments to the integration of computer technology into the school system.

The pilot project participants identified lack of access to hardware, lack of courseware, and lack of training and in-service opportunities as the factors which had made it difficult for them to meet their objectives. As all the participants in the project were using the same microcomputer, there were few problems associated with diversity of hardware systems. The majority of the teachers in the project were very enthusiastic and indicated that they would like to continue to be involved in the use of microcomputers in education. However, although the attitude of the teachers in the project was favourable, there was no measure of the attitude of teachers in the province who were not involved in the project.

Of all the potential applications for the computer in education that have been identified in the literature, participants in the project used the microcomputers for administrative, professional development, library, testing, instructional aid, instructional management, computer literacy and computer awareness, computer science, and computer assisted instruction applications. This identifies nine of the dozen potential applications described by Watts (52).

The general concensus of opinion among pilot project participants and the Project Team was that microcomputers, with solid and continuous field support, should be introduced into the school system at the primary level in numbers per classroom increasing over time as teacher familiarity increases, as the quality of courseware improves, as more becomes known about the effective uses of the computer in education, and as the finances of the province and the school districts permit.

It was also the general concensus of opinion that these microcomputers should be used primarily for computer assisted instruction including the provision of courses new to a district,for courseware development, for teacher training purposes, and for administration. It was also recommended that a major rationale for the introduction of the microcomputers into the schools should be the promotion of computer literacy and computer awareness among the students and teachers of the province.

Thus, although information was gained which helped to answer some of the questions posed at the beginning of the project, and although more information was added to the body of the literature on the subject of computers in the instructional process, the participants in the project and the members of the Research Team have been left with an awareness of another set of questions that need to be answered, questions that are the result of a year's experience with microcomputers in the field.

In their identification of major impediments to their having reached their original objectives, teachers identified the major impediments as 1) lack of access to microcomputer systems; 2) lack of courseware; and 3) lack of knowledge.

In their recommendations for support components for future microcomputer development within the province, approximately 75% of the teachers felt that financial assistance for hardware and peripheral purchase was essential, 65% were of the opinion that the development of B.C. specific courseware was essential, and 50% identified the evaluation of commercial courseware, the adaption of commercial courseware to the B.C. curriculum, the encouragement of the local development of courseware, in-service training, and financial assistance to establish coordination in the province as essential (Table 17).

It is recommended therefore that the Ministry continue to provide support for the continued exploration of the instructional use of microcomputers in the province through contracts with outside agencies, associations, or organizations until such time as the future of microcomputer use in the province has been stabilized. As soon as stabilization occurs, it is recommended that the Ministry establish, according to a careful plan, an organizational structure within the districts and the department of education to provide support for computer using educators in the province and to take advantage of the organizations that already exist.

It is also recommended that the central support agency address the needs that were identified in the formative evaluation and confirmed in the summative evaluation through the provision of the support services that are described in the rest of this report.

Recommendations

1) As the impediment that was felt to be the most significant was the lack of microcomputer systems, it is

recommended that the Ministry continue to provide cost-shared support for the purchase of microcomputers and peripheral devices.

2) As the single most critical issue in the use of the microcomputer in the schools of B.C. is the acquisition, development,and sharing of quality CAI materials relevant to the B.C. curriculum, it is recommended that the Ministry provide financial support to an organization which will evaluate and describe commercially available courseware with reference to its quality and its specific and documented relevance to the B.C. curriculum. Where possible, bulk purchase arrangements should be negotiated for exemplary courseware as should the rights to modify commercial courseware to make it more relevant to the curriculum.

3) To promote the development of courseware, the central organization should document areas where commercial courseware correlates with specific areas of the curriculum, and should advertise to the field and the courseware developers areas where courseware is needed. The same organization which evaluates commercial courseware should evaluate courseware that is locally developed according to the standards already established by the Curriculum Development Branch. Courseware development efforts should concentrate on areas where the research has shown CAI to be both effective and cost effective. There should be organized coordination for the development of quality courseware employing the expertise of subject area and computer specialists, and the resources of the Curriculum Developmet Branch. In supporting this organized effort, the province should provide, either through release time or substantial financial assistance , support for teachers or teams of teachers who are working on the development of courseware, and should provide professional recognition of the efforts of educators who have contributed to the development of courseware for the use of the teachers in the province. A delivery system should be established to ensure that these programs are advertised and distributed to the field with the appropriate support materials to ensure their effective integration into the curriculum and the classroom.

4) The information network which had begun to connect all educators using computers to a central source where information could be collected and disseminated should be

continued and expanded to include a computerized enquiry and bulletin board system.

5) The Ministry, the Universities and the Colleges must continue to support and provide a coordinated in-service training effort that will closely monitor the computer literacy level of all teachers in the province and provide for the different levels of interest, expertise, and experience within the province. To guarantee that such in-service efforts provide equal opportunities for teachers in remote areas, and to take advantage of the cost-effectiveness of high technology, it is recommended that some components of in-service training be developed on microcomputers, on interactive videotape, and employing the resources and expertise of the knowledge network.

6) The central support agency must continually monitor, evaluate, and use new hardware and software systems to be prepared to answer questions that will come from the field as teachers hear about the new products.

7) The central agency should continue to monitor and evaluate the new hardware products that are continually available and to assess their usefulness in the learning situation, particularly with reference to mini- and microcomputer networking and videotape and videodisk technology.

8) It is essential that the Ministry continue to evaluate the educational potential of centralized and distributed systems for instructional technology and to monitor the progress of such systems as Telidon.

TABLE 17

COMPONENTS FOR FUTURE MICROCOMPUTER DEVELOPMENT

The first column represents the % of teachers, the second the number of coordinators.

	Not important		Somewhat important		Important		Essential	
Evaluation of commercial courseware	-	-	6.3	1	40.5	1	53.2	10
Adaption of courseware to B.C.	0.9	-	14.3	1	37.5	5	47.3	6
Bulk purchase augmentation and distributorship	7.6	-	23.8	-	33.3	3	35.2	9
A courseware delivery system	0.9	1	11.1	-	44.4	4	43.5	7
Identificating courseware voids	2.8	1	16.8	2	43.0	6	37.4	3
Development of B.C. specific courseware	-	-	5.4	-	30.6	3	64.0	9
Evaluation of local courseware	3.7	-	18.3	2	44.0	6	33.9	4
Encouragement of local courseware development	0.9	1	22.7	3	27.3	3	49.1	5
Information networking	5.4	-	20.7	3	42.3	3	31.5	6
In-service training	-	-	10.7	-	36.6	2	52.7	10
Financial assistance for hardware and peripherals	-	-	5.4	-	19.8	2	74.8	10
Financial assistance to establish coordination	0.9	-	21.7	2	30.0	4	56.4	6

SEARCH OF THE LITERATURE

Search of the Literature

A search of the literature reveals that most educators would agree with Splittgerber (45) that the instructional utilization of microcomputers can generally be divided into two broad categories, namely, computer managed instruction (CMI) and computer assisted instruction (CAI):

> The latter, CAI, is defined as a teaching process directly involving the computer in the presentation of instructional materials in an interactive mode to provide and control the individualized learning environment for each individualized student. These interactive modes are usually subdivided into drill-and-practice, tutorial, simulation and gaming, and problem-solving....
>
> In contrast, CMI is defined as an instructional management system utilizing the computer to direct the _entire_ instructional process, including perhaps CAI as well as traditional forms of instruction which do not require the computer such as lectures and group activities. CMI has some or all of the following characteristics: organizing curricula and student data, monitoring student progress, diagnosing and prescribing, evaluating learning outcomes, and providing planning information for teachers. (Splittgerber, p.20)

The definition of CAI has been further refined by Chambers and Sprecher (11) to distinguish between adjunct and primary, simplistic and complex CAI. According to these researchers, adjunct CAI refers to a program or series of programs which supplements the learning situation whereas primary CAI describes programs which provide instruction of a substitute or stand alone variety. Simplistic CAI can be developed by using easy-to-learn programming languages but complex CAI requires authoring which permits such features as the extensive use of graphics and large scale calculations.

However, for the purposes of this discussion, the terms CAI and CAL will be used interchangeably to include the broad range of possible applications of computers in education. The remainder of this section of the report will review the current literature regarding the use of computers in education.

The Effect of CAI on Achievement

Arguing against the need to prove over and over again that CAI "works", Eisele (18) points out that there is "little likelihood that sufficient evidence will ever exist that will assure educators - with any noticeable degree of confidence - that any delivery system will perform adequately if the criterion is stated in replicable learner performance" (Eisele, p.1).

Similarly, Gleason (21) observes that few serious researchers are now interested in comparative studies, i.e., studies which attempt to compare the results of computer assisted instruction with the results of other strategies because of the extreme difficulty of controlling the number of significant variables in any learning situation (Gleason, p.16).

Aiken and Braun (1) argue that although the trend has been to use statistical techniques to measure the effectiveness of CAI materials, they feel that attitudinal studies would appear to be a more promising approach. They point out that "statistical results have been meaningful only as measures of performance; other methods will have to be considered if we are to have meaningful measures of learning" (Aiken and Braun, p.14).

However, although researchers caution against placing too much emphasis on statistical results, decision makers are demanding proof that CAI is effective, often without fully understanding what they mean by "effective".

As Chambers and Sprecher (11) point out,

> To some effectiveness means the amount of learning that takes place initially. To others it means the degree of retention of learning, or at the very least, whether or not an individual stays in or drops out of a learning experience. Still others are concerned with the learner's change in attitude toward the computer as an instructional medium or simply as a helpful tool in the culture. Finally, owing to the fact that

> CAI is in its infancy, some are simply concerned with transportability of materials and/or acceptance of the materials for use by others. (Chambers and Sprecher, p.335)

To further complicate the issue, the number of methodologically sound evaluations of the effectiveness of computer assisted instruction are rare and conclusive results are difficult to find.

However, there are a number of well designed and tightly controlled studies from which some generalized conclusions can be drawn regarding the effectiveness of CAI in the learning process:

1) The use of CAI either improved learning or showed no difference when compared to traditional classroom approaches (9,16,17,20,23,29,34,41,50).

2. The effect on achievement occurred regardless of the type of CAI used, the type of computer system, the age range of the students, or the type of instrument used to make the measurements (Hallworth and Brebner, p.175).

3. When CAI and traditional instruction are compared, equal or better achievement using CAI is obtained in less time (16,17,20,29,34,42).

4. Students have a positive attitude towards CAI, frequently accompanied by increased motivation, attention span, and attendance in courses (Hallworth and Brebner, p.178).

In addition to the above consistencies, a number of other interesting and significant factors relating to the effectiveness of CAI are reported in the literature:

1. Tutorial and drill modes seem to be more effective for low-ability students than for

middle or high-ability students (8,16,17,20,26,42);

2. Many reluctant learners become active and interested learners when involved in computer supported programs (20,26);

3. The bulk of the studies showing CAI to be effective have concerned the use of adjunct CAI in which the classroom teacher was readily available (11);

4. Poor attitudes on the part of instructors and administrators have resulted in overt sabotage to the computer learning process (14);

5. Foreign languages and science are two areas in which CAI programs consistently have been shown to be effective (17);

6. CAI is helpful to students reviewing materials with which they had prior familiarity (17); and

7. Retention rates may be lower than for traditional means (45).

Although a number of fundamental questions regarding the effectiveness of CAI have been answered, an increasing number of researchers are arguing that there are many more complex questions that still need to be explored and that more subjective, less quantitative approaches are going to have to be used (1,11,13,14,18,21,31,42).

The types of questions that educators and administrators are currently asking of the research are concisely summarized by Gleason (21):

1. What are the most effective CAI strategies? What type of feedback is most effective? How often? At what point in the program? What

types of learner interaction are most productive? Which instructional paradigms are most effective in the various content areas?

2. What are the interactions of individual learning styles in CAI? How much cognitive complexity can the learner manage? What concept-learning strategies are most appropriate for which types of learners?

3. What are the effects of individual learner characteristics, such as memory span, perceptual skills, sensory preferences, intelligence, motor-skills, etc.?

4. Which hardware configurations are most effective and efficient in various types of program? Audio? Touch-sensitive screens? Videodisc? Light pens? Etc.

5. What affective characteristics of the learner are important? Motivation? Persistence? Delayed gratification? Locus of control? Etc.

6. What are the most effective strategies for program development?

7. What are the most effective strategies for integrating CAI with other instructional activities? (Gleason, p.16)

The answers to these questions will provide further information regarding the development of courseware and the integration of instructional technology into the classroom. In the meantime, educators can continue to plan and implement computer programs on the basis of studies that have been completed. As Paden (41) points out,

> If the profession is serious about improving instruction, these experiments provide tips galore: use the computer to improve study habits,

> to highlight important concepts, to process data, to "individualize" instruction, to give examinations, to provide prompt feedback to students, to keep records, and to add pizzazz to content instruction. Some of this will improve performance. Some of it will improve student attitudes. Other aspects will reduce the drudgery of teaching for the instructor. (Paden, p.18)

But he also cautions, as does a search of the literature on the effectiveness of CAI, that expectations of greatly improved performance from CAI presented as an addition to conventional instruction seem unrealistic.

Dence (17) expresses a similar opinion in regard to the most effective current and future use of CAI in the instructional setting. She points out that current studies in ATI (Aptitude-Treatment Interactions) are attempting to identify ways to measure individual student characteristics to determine which approaches will benefit students with specific characteristics. Educators have begun to identify the student characteristics such as response pace, initial levels of achievement, and prior familiarity with subject matter as characteristics that respond well to CAI, and Dence suggests that further research in areas such as locus of control, split-brain research, cognitive style, anxiety level,and personality types will assist educators in designing courseware and in making recommendations for the effective use of CAI in educational settings. She adds that "where significant differences are found between CAI and traditional instruction, it is imperative to identify and quantify why those differences occurred," (Dence, p.54).

She concludes:

> The results of direct research will have a great impact on the use of CAI by extending the interpretation and applicability of prior findings. CAI can then be used in those situations where the indication is that it will enhance learning for individual students or groups of students. More traditional methods of instruction can be retained for those situations where they are the most effective (Dence, p.54)

The Cost Effectiveness of CAI

Kearsley (29) has pointed out that although CAI may be perceived as instructionally effective, educators may be reluctant to use it if they perceive it as being prohibitively expensive. Economically, the debate over the uses of CMI and CAI focuses on 1) the relative advantages that the computer has over traditional, perhaps less expensive instructional methods; 2) whether, in fact, less expensive means are available to effect the same instructional gains as the computer; and 3) whether technological advances have reduced the costs to a point where school districts can implement computer based instruction (Splittgerber, p.21).

Cost estimates for CAI are highly variable and are difficult to establish with any degree of accuracy, particularly as CAI can be delivered on a variety of timeshare or microcomputer hardware systems. There have been a number of studies which have assessed the cost effectiveness of timeshare systems (6,7,8,11,23,29), but studies providing information regarding inexpensive microcomputers and commercially available courseware are difficult to find.

However, regardless of whether CAI is being delivered via timeshare or microcomputer technology, the hardware purchase and maintenance costs, the courseware purchase and courseware development costs, and the cost of the provision of training and support services to educators must be taken into consideration in any estimate of the cost effectiveness of CAI over traditional instructional methods.

More specifically, estimates of cost effectiveness need to consider hardware purchase and maintenance costs as amortized over the number of years of use the system is intended to provide and as distributed over the number of students who will be using the system.

Similarly, courseware acquisition and development costs are dependent on a number of factors which influence any estimate of the overall cost effectiveness of CAI. For example, software development and acquisition costs are

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reduced in proportion to the number of students using the courseware, particularly if the courseware is being provided for handicapped or remote students who have traditionally been more expensive to educate than regular students. Costs are also reduced if the courseware is simple in design and if it has a long lifespan uninterrupted by updates or revisions. Whenever possible, it is generally more cost effective to purchase commercially available courseware than to develop it.

In addition, any decision regarding the cost effectiveness of CAI must take into consideration whether the courseware and the costs are being incurred to replace, or to add to regular instruction.

These variables have made it difficult to assess the cost effectiveness of CAI, particularly with the newer microcomputer technology.

It has been estimated that a very adequate stand alone system costing $5,000.00 to $6,000.00 and used for 1500 hours throughout a school year will cost 50 cents an hour. Courseware development cost estimates range from 50 cents to $750.00 per student hour (11,23). Courseware acquisition costs are highly variable, ranging from $3.00 for a single program to $600.00 for a series of programs that can be used by an entire elementary school, but 50 cents an hour would be a generous estimate. Therefore, whether courseware is acquired or developed, the cost of CAI using a microcomputer hardware system can be estimated at $1.00 a student hour. Hallworth and Brebner (23) estimate that timesharing computer cost is between 66 cents to $1.00 per student hour. They point out that when 16 bit microprocessor systems become available, with multi-user software using hard disks, these should support up to at least 16 users on a school CAI system and it may be reasonably expected that for this number of users, and possibly for a smaller number this system will reduce the cost per student hour to 20 cents or less. With the overall cost of education per student hour for the Calgary Board of Education being $2.22 with $5.56 for special education students (23), CAI, whether on timeshare or a microcomputer system, compares very favourably.

Norris (39) has pointed out that traditional instructional costs have been increasing at the rate of 13%

a year for the past three years while CAI costs have been decreasing at 5% per year, coupled with a 10% improvement in performance. Hirschbuhl (26) also points out that "in a period of run-away inflation on a nearly global basis, the per character cost of computer technology has been reduced a thousand fold, the reliability increased twenty fold, and the accessibility increased by a like magnitude" (Hirschbuhl, p.62). He estimates that by 1990, computer industry hardware will become 32 times as cost effective as present day hardware. It can be safely assumed that as hardware capabilities increase and costs decrease, CAI will become more and more cost effective.

In addition, the hidden benefits must be considered. Braun (8) reports that in a computer program in the District of Columbia in which 700 students were involved, there was an increase in student attendance at a tax cost saving to the public of $30,710.00. Extrapolating this to the entire student population, Braun argues that the productivity gain would be on the order of $1 million per year. Similarly, based on a study on attrition in a community college system in Ontario, Braun estimates that by using CAI mathematics the province's dollar gain or cost-productivity gain index per year would be $9,600,000.00 He concludes that "the value of these two studies is that they demonstrate that the use of the computer to aid instruction can result in a substantial gain in the use of the tax dollar for education" (Braun, p.10).

It has also been pointed out that hardware originally purchased for CAI has been doing double duty in administration, guidance, record keeping and library functions; that truancy and vandalism were reduced in schools where CAI was being used with disadvantaged students; that by using the computer, educational institutions can offer more flexible scheduling and wider course alternatives; that curricula can be more attuned to the pace of change; that instructor costs are saved in providing distance and continuing education; and that new knowledge can be brought into education much sooner (8,11,23,29,39).

The hidden costs include maintenance costs for hardware, the inevitable higher costs for courseware development which are anticipated to account for over 90% of total costs by 1990 (23), and the cost of a support mechanism to introduce and integrate CAI into the instructional setting in a manner which guarantees the benefits which have been shown to be possible.

If the cost estimates of CAL are adjusted to include the hidden costs of software, courseware, inservice, maintenance, and support, they may well be higher than traditional per-student-hour costs. They must, however, be weighted for their cost effectiveness. Deltak, Inc. compared their industrial training programs and found that a five day instructor lead course of 10 students was more costly than a computer enhanced, learner-paced multi-media approach at a ratio of $1,120.00/$680.00 (42). That is, traditional training is 65% more expensive than CAL.

Kearsley, in his article "The Cost of CAI: A Matter of Assumption," concluded:

> The fact that CAI results in a higher per student hour cost is based upon a fairly dubious assumption that the instructional effectiveness of CAI is the same as traditional instruction. This is most certainly an invalid premise. Almost all comparative studies of CAI have shown that it reduces the time required for a subject by 25-50 percent while still resulting in the same end performance. CAI permits a very detailed monitoring and evaluation of student performance and instructional effectiveness which is essentially impossible in traditional instruction. CAI also permits certain kinds of instruction which could not be done by any traditional means (e.g., medical simulations of dying patients). Students are overwhelmingly positive about CAI, and they express strong preferences for this mode of instruction across all subjects. Thus, an hour's worth of CAI may be instructionally equivalent to two hours or more of traditional instruction. If we accept this, then cost estimates which show CAI as costing the same as or slightly more than traditional instruction in fact give CAI the edge (21).

When used as a substitute or replacement for traditional methods, particularly when considering the education of special students, CAI can be cost saving. However, at the present time, CAI is used today mainly as a supplement to regular instruction either in enrichment or remediation and as such, its costs must be considered as add-ons to traditional instruction. Considering the benefits, educators must ask whether the added expense is worth it.

Further Considerations

In addition to the effect that CAI reportedly has on achievement and education costs, a search of the literature reveals that researchers have identified a number of other factors that can be identified as advantages to CAI.

These advantages include the computer's ability to individualize the instructional process (34); to simulate experiences not possible at all without a computer (13,29,34); to keep students informed of their progress through immediate feedback and achievement summaries (34); to provide immediate and systematized reinforcement; to provide instruction that has been systemmatically prepared, sequenced,tested, and revised (34); and to allow students to review previous instruction, request special help, or to continue on to enrichment activities (34).

In addition researchers argue that because the computer involves the individual actively in the instructional process, learning is facilitated (11); and that CAI frees the teacher to devote more time to the personal, human considerations of their students, a factor which has been identified by Chambers as being the most significant in the development of creative abilities, according to students (12).

The rationale for introducing computers into the schools on the basis of cost effectiveness and instructional benefits is a potent argument, particularly in light of the public's perception in Canada and the U.S. that the educational system is both costly and unsatisfactory.

Braun (8) identifies a number of factors which indicate the public's dissatisfaction with the education system in the U.S. These factors include the significant increase in the number of drop outs; an increase in the numbers of students who are performing below their grade levels; unacceptably high levels of youth unemployment; a continuing decline in the education of U.S. students in the sciences; and the spiralling costs of programs for the education of the handicapped, the gifted, and the learning disabled.

He offers the arguments of Dr. Dustin Heuston of WICAT as further rationale for the immediate and widespread introduction of the computer into the present educational system. In "Technology and the Educational Delivery System", Heuston points out that

> 1) The current U.S. educational system is insensitive to additional investment and cannot be improved without the dramatic change producible with new technologies.
>
> 2) The current educational delivery system provides about 15 seconds of personal attention per hour whereas with computers that proportion could reach almost 100%.
>
> 3) After expensive and extensive efforts at improvement, the present educational system has reached its maximum effectiveness.

Thus Braun and Heuston argue that the only effective means of increasing the productivity of the present educational system is through the introduction of technology into the instructional process, and as Braun points out, computers will move into homes and schools whether or not anyone does anything to ensure their effective use.

Splittgerber (45) summarizes:

> Supporters forecast an imminent breakthrough in the use of computers due, primarily to decreasing costs and increased availability of minicomputers; curricula and software improvements; the trend toward accountability; the requirement for improved school productivity; and the expansion and personalization of instruction (Splittgerber,p.25)

The Computer Literacy Argument

Perhaps the most powerful argument for the immediate and widespread introduction of computers into the school system is Luehrmann's argument (32) that "the ability to use computers is as basic and necessary to a person's formal education as reading, writing,and arithmetic" (Luehrmann, p.98). He contends that computing plays such a crucial role in every day life and in his nation's technological future that "the general public's ignorance of the subject constitutes a national crisis (Luehrmann, p.98).

The requirements for living and working in what has been called The Age of Information have been clearly described by Andrew Molnar (36) who argues that "if we are to continue to benefit from the expanding frontiers of knowledge, we must devise new ways to expand human capacity and reasoning .... and we must create new intellectual tools to extend human capacity to reason".

In his presentation, "Education for Citizenship in a Computer-Based Society", Daniel Watt (51) points out that although in the past only a small percentage of the population ever had direct contact with computers, in the future, as the nation's economy becomes more dependent on information processing and high technology, "we can expect the overwhelming majority of our working population to have significant interactions with computers as part of their daily work" (Watt,p.2). He insists that "only public schools can help insure that all citizens have equal access to the opportunity for computer literacy education, and only the public schools in our society have the responsibility for the education of citizens who can make effective decisions about the impact of technology on society" (Watt,p.6).

The important point being made is that computers will soon be everywhere and students who have not been exposed to them will be at a decided disadvantage when competing with those who have; and society generally will be at a disadvantage when confronting issues that have to do with the impact of computers on the individual and on society. In short, our students must become computer literate.

The definition of computer literacy has been evolving as educators and researchers have become more knowledgeable about what it means to be literate and as computers extend further and further into society.

Initially, when computer literacy was identified in 1977 as one of the Ten Basic Skills by the American Council of Supervisors of Mathematics, computer literacy was generally described as what students should know about the uses of computers and what computers can and cannot do (40).

The Human Resources Research Organization (HumRRO) defined computer literacy as what a person needs to know and to do with computers in order to function competently in our society (38). The University of Oregon advised that computer literacy referred to the non-technical and low-technical aspects of the social, vocational, and educational implications of computers (38).

However, it is generally believed that these definitions no longer suggest adequate goals and objectives for a computer literacy program. As David Moursund points out, computer literacy initially tended to mean a level of understanding at which the student could talk about but could not actually work with a computer (38). However, this level of understanding is now considered to be computer awareness rather than literacy.

Luehrmann (32) argues that computer literacy must mean the ability to do computing and not merely to 'recognize,' 'identify,' or 'be aware' of alleged facts about computing that have been supplied by a book or a teacher. Further, he states that "it is intellectually improper to inculcate beliefs and values about a subject that do not arise out of direct experience with the cotent of that subject" (Luehrmann,p.6).

Based on an interpretation of the common meaning of literacy and following a traditional understanding of what it means to be literate, Daniel Watt (50) defines computer literacy as "that collection of skills, knowledge, values and relationships that allows a person to function comfortably as a productive citizen of a computer oriented society" (Watt,p.26).

He further divides the concept of computer literacy into four distinct but interrelated areas which, summarized, include:

1) The ability to control and program a computer to achieve a variety of personal, academic and professional goals;

2) The ability to use a variety of preprogrammed computer applications in personal, academic and professional contexts;

3) The ability to understand the growing economic, social and psychological impact of computers on individuals, on groups within our society, and on society as a whole; and

4) The ability to make use of ideas from the world of computer programming and computer applications as part of an individual's collection of strategies for information retrieval, communication and problem solving (Watt,p.27).

Watt concludes that "the failure of schools to make a major commitment in this area now can have disastrous consequences for both the education of the public and the future of public education" (Watt,p.27).

Impediments To Implementation

If the evidence for the widespread and immediate introduction of computers into the school system is so overwhelming, why is there such a gap between the actual and the potential use of computers in education? A search of the literature reveals that there are a number of factors which researchers have identified as being impediments to the exploration of the full potential of the computer in education:

1) Insufficient funding from the appropriate sources to support the original purchase of hardware, software, courseware, and to establish the necessary support services for the successful integration of the technology into the educational system (13,29,33,37,45).

2) The primitive state of the art in which there is a confusing diversity of languages and hardware systems (11,29).

3) CAI materials that are poorly constructed, largely undocumented, and able to run only on the equipment for which they were written (11,29).

4) Lack of knowledge among educators as to how to effectively use CAI materials and the computer in the learning situation, particularly at the moment when limited financial resources restrict the number of systems available per classroom (11,29,37).

5) The attitude among teachers, familiar with and comfortable using tried and tested methods, that the computer is not a tool but an intelligent machine destined to replace them as teachers (11,14,29,45,48).

In order of importance, Chambers and Bork (13) found the impediments to the implementation of computer assisted instruction to be 1) funding; 2) lack of knowledge about computer assisted instruction and computers in general; 3) attitudes of faculty; and 4) the need for more and better computer assisted instruction modules (Chambers & Bork, p.28).

In addition to the above impediments to the implementation of computer assisted instruction, critics cite the lack of information about the effectiveness of CAI, the tremendous financial commitment to a technological innovation that is new, untried and uncomfortably similar to educational television, depersonalization of the educational process, and lack of support from teachers and teacher's organizations as reasons why it is advisable to adopt a wait and see attitude.

Potential, Actual, And Projected Uses Of The Computer In Education

A search of the literature reveals that there are various applications which have been identified as being reasonable and effective uses of the computer in education. As described and envisioned by such researchers as Bork, Franklin, Haugo, and Watts, these applications include the following:

1) Administrative applications which include such activities as keeping track of accounting, payroll, inventory and employee records and of attendance, grades and student records. The computer has also been used in administration in class timetabling and in simulating models to forecast the implications of decisions and changes in the educational environment (6,24,49,52).

2) Curriculum planning applications such as the resource information file which was developed and is being used in ALaska to provide teachers with information on available educational resources (49).

3) Professional development applications which not only provide teachers with new skills and an understanding of the uses of computers in education, but could also provide highly informative and imaginative professional development courses in other areas of education (52).

4) Library applications which involve the computer in maintaining records of holdings, managing intra- and inter-library loans, and enabling users to search files for relevant titles and information (52).

5) Research applications which enable a school or district to analyze data collected on a regular basis or for special purposes (52).

6) Guidance and special services applications which include computer administration and scoring of

selected standardized tests; provision of guidance and career information using a computer; and the administration of tests and the analysis of data to assist special education personnel with the diagnosis and remediation of learning problems (52).

7) Testing applications which include computer assistance in the construction, administration, scoring, and evaluation and analysis of test results (6,52).

8) Instructional aid applications which are described by Watts (52) as the use of the computer in the same manner that any audio-visual device or piece of laboratory equipment may be used to demonstrate or illustrate concepts or to allow students to manipulate parameters without having to duplicate a real world situation.

9) Instructional management applications which assist the teacher in providing individualized or small group instruction by using the computer to manage the student's learning experiences and to monitor and assess progress (1,6,24,45,52).

10) Computer assisted instruction applications which involve the computer in taking over a central part of the instruction of the student (1,6,24,45,52) and which can include a number of different modes of interaction with the student:

> 1) Drill and practice programs take advantage of the computer's tireless patience and ability to provide immediate feedback and reinforcement to prescribe, provide, and monitor potentially very complex drill and practice activities which can be tailored to a student's individual needs.
>
> 2) Tutorial programs, depending on the capabilities and the storage capacity of the computer system, are dialogues between the learner and the designer of the educational program. The computer acts as a 'tutor' to teach the student concepts and skills. The worst of such programs

are simply page turners which present passages of text and then ask the student to answer a question on what they have just read. The best type of tutorial, called 'dialog', leads the active learner through a series of carefully planned questions to some new understanding or knowledge of the topic at hand.

3) Simulations or controllable worlds are programs in which the computer can be used to simulate or generate environments for the learner so that he can change variables and explore situations in a manner that might have been too expensive, too restricted by time limitations, too dangerous or too impossible to allow the student to explore in the real world.

11) Computer awareness and literacy applications which involve the computer in preparing students to understand and to be able to use computers in our future computer oriented society.

12) Computer science applications which include teaching students about computer architecture, operations, programming, and applications (52).

Chambers and Bork (13) selected a sample of 974 school districts which closely approximated the total population of U.S. public school districts to assess the current and projected use of the computer in U.S. public secondary/elementary schools, with special emphasis on the use of the computer in computer assisted instruction (Figure 1).

It was found that approximately 90% of all school districts responding are now using the computer in support of the instructional process. Most computers are leased or owned by districts and large computers are more in evidence than are micros and minis which the study found to be equal in popularity. It was also found that the most popular applications in order of usage are the teaching of computer languages, computer assisted learning, data processing applications, using the computer as an instructional aid, and using it for guidance and counselling applications (Chambers & Bork, p.11)

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FIGURE 1

TRENDS

(U.S. EXPERIENCE)

	% of School Districts Sampled
1. Districts Using Computers	1980 - 90% 1985 - 94%
2. Instructional Usage	1970 - 13% 1980 - 74% 1985 - 87%
3. CAL	1980 - 54% 1985 - 74%
4. Application Priority	1. Math 2. Science 3. Language Arts 4. Business
5. Emphasis Shift Drill and Practice → Tutorial → Simulation	

Source: ACM Report on CAL
Chambers/Bork 1980

In computer assisted instruction applications, the predominant use is in drill and practice, although it was noted that simulations are also receiving a good deal of use. At the secondary level, predominant use is occurring in Mathematics, Natural Science, Business, and Language Arts (Chambers & Bork,p.15).

Chambers and Bork's study showed a dramatic change form the past. From an estimated 13% in 1970, instructional computer usage had leaped to 74% in 1980 with the type of instructional usage changing from predominantly problem solving and the acquisition of EDP skills, to a much heavier emphasis on computer assisted instruction. They also found that while the quantity of instructional computer usage in the schools had increased significantly, the richness and diversity of usage had not increased proportionately. They attribute this to the industry's concentration on providing hardware to the schools while not being able to provide adequate and satisfactory courseware to support the use of the hardware, and to the lack of adequately trained staff to enable effective use of the computer in CAI.

For the period 1980-1985, 94% of the districts surveyed anticipated using the computer with 87% of this percentage indicating that they would be using the computer to provide support for instruction. Types of instructional usage were projected to continue as in the past with 74% of the districts indicating that they would be providing computer assisted instruction. It was also anticipated that tutorials would assume greater usage with drill and practice receiving less. Chambers & Bork suggest that this shift in emphasis will perhaps move towards simulation by 1990. In support of Chambers and Bork's findings is Hirschbuhl's table which projects increased levels of acceptance and utilization areas for CAI by 1990 (Figure 2).

Watts (63) points out that there are schools in which a dozen applications of the computer in education are already to be found and he concludes, "the challenge is there for all schools to successfully introduce computers and to develop their potential in education" (Watts,p.22).

FIGURE 2

LEVELS OF ACCEPTANCE AND UTILIZATION AREAS FOR CAI

	HOME PRESCHOOL	SECONDARY SCHOOLS	HIGHER EDUCATION	INDUSTRY	COMMUNITY INST.
1977 ACCEPTANCE	Zero	Widely dispersed emerging	Widespread	High level limited implementation	On the horizon
1977 UTILIZATION	None	Basic skills (heavy)	Skill and survey type instruction (moderate)	Testing and training drills (light) Basic skills and conditioning programs (light)	Vocabulary and procedural info. in health areas
1990 ACCEPTANCE	Widespread	Widespread	Universal	Heavy	Broad by social and health institutions
1990 UTILIZATION	Heavy use in concept development	Universal for skill development and high level concept development	Extensive for entry level courses and high level professional development and continuing education	Heavy in specific training skills and management development	Heavy use by health industry for upgrading diagnostic skill Heavy use for rehabilitation and deterrent programs in criminal justice

Source: Hirschbuhl
Educational Technology 18,4(1978), p62.

Future Trends And Recommendations

A search of the literature indicates that most educators and researchers are cautiously optimistic about the future of computers in education.

As discussed earlier, the major impediments to the widespread introduction of computers into the education system are

1) insufficient funding to purchase hardware and courseware;

2) insufficient and inadequate courseware that has been designed to run only on one system;

3) the confusing diversity of hardware systems and languages;

4) lack of knowledge among educators as to how to effectively use the computer in an educational setting; and

5) the concern of teachers that the computer is either too difficult for them to learn to use or that it is destined to replace them in their job.

Although Chambers and Bork report that "it is predicted that by 1985 the current major problems in the use of computer assisted learning will have been reduced to the level that the hardware problem has now reached in 1980" (Chambers & Bork), at the moment, the above impediments must still be considered major concerns.

It is generally agreed that hardware barriers have been or shortly will be resolved and cost reductions will help eliminate funding problems and permit the cost effective use of CAI (2,4,10,11,26,29,31,39). In support of this prediction, Gleason (21) reports that a recent study by the National Science Foundation estimated that there are already 200,000 microcomputers in American elementary and secondary schools and projects one million units by 1985.

It is also generally agreed that the technology for instructional use in educational settings will likely include mini- and microcomputers capable of standing alone or networked and incorporating a touch sensitive input device, image projection, colour printing device, voice input and output, interactive television, videodisc systems and satellite communication. According to the research, videodisc technology will play an increasingly significant role in creative and effective innovations in education.

A number of researchers - Atkinson, Bunderson, Hirschbuhl - predict distributed networks with large shared databases which would enable individuals to use stand-alone microcomputers or access larger databases or communicate with other users.

Hirschbuhl (26) argues that, "the power of interactive visual, sound, computer simulation, control, and change of variables along with the mind extending ability of computer prediction offer teaching capabilities never before realized" (Hirschbuhl, pp.52-53). He envisions brain waves used as input to Computer Assisted Dialogue CBE systems, laser libraries for the visually handicapped, talking computers to provide books for the blind, listening computers that understand unconstrained natural speech, in short, applications that will have far reaching implications for education.

Although it is generally accepted that hardware is going to be the most easily solvable problem in implementing CAI in the future, it is still considered to be absolutely essential that 1) educators constantly monitor new hardware products and their potential usefulness to CAI, and that 2) wherever there is a central organization planning the activities of a group of computer using educators, there should be uniformity of hardware and cost reducing bulk purchasing arrangements with manufacturers.

Although Atkinson (2) believes that "by 1990, the cost of computer-assisted instruction will be so cheap and its applications so broad that it will be viewed as an educational necessity"(Atkinson,p.60), Bitzer (4) points out that "the next steps in producing useful educational computer technology are far more complex and include some of the most difficult applications of a computer" (Bitzer, p.61).

He agrees that limited applications that can take advantage of increased low-cost technical capabilities are already available but argues that hundreds of different stand-alone systems are not going to provide an "educational system consisting of high quality material organized in an overall educationally efficient manner" (Bitzer,p.61). He believes that the most difficult questions must still be answered and that we cannot afford to underestimate how much those answers are going to cost.

The first of these problems is the continuing diversity of hardware systems with their differences in languages and their limitations in only running the courseware that has been written for that system. Although some researchers believe that this will continue to be a problem, Attala (3) argues that hardware advances in the development of microprogrammable chips containing compilers for several kinds of authoring languages and of replaceable read-only memory chips for the easy modification of system software will "solve the problem of transferability that has hindered for so long the propagation and popularity of CAI" (Attala,p.61). Chambers and Sprecher (11) recommend the development of a nationwide, standard high-level CAI language for complex CAI development which incorporates authoring aides, computational capability, graphics capability, multisensory input/output controls, and prescribed documentation standards. They believe that such a language should be easy to use and should be capable of running on large, mini-, and microcomputers. Because the development of such a language would be in the national interest, they argue that it should be funded by the federal government with the impetus coming from the educational sector and possibly incorporating a cooperative venture with the private sector.

The second major impediment, and considered by some to be the most serious, is the lack of a sufficient quantity of high quality courseware. The problem of portability of software and courseware which restricts the market, the copyright problem, the tremendous amount of time required to develop materials, and the need for experienced and qualified educational and computer professionals are factors working against a solution to this problem. As discussed above, the problem of the portability of courseware could possibly be solved through the development of a standard CAI language or through hardware advances which may also solve the copyright problem.

But the problems associated with the amount of time needed to develop materials and the difficulty in finding qualified and experienced instructional designers and computer programmers still exist. Gleason (21) warns educators that contrary to what they may have been told, courseware development is not easy:

> It involves careful specification of objectives, selection of programming strategies, detailed analysis of content structure and sequence, development of pretests and posttests, preliminary drafts, revisions, trials, validation, and documentation. This is a very time-consuming and expensive process, well beyond the capability and resources of individuals and even small groups of teachers (Gleason, p.12).

He points out that at the present time there is no comprehensive, systematic, or effective organization to prepare good programs, and although there are thousands of programs being written, "most are virtually devoid of any instructional value and in many cases are acting as deterrents to widespread acceptance of CAI" (Gleason,p.12).

Chambers and Sprecher (11) found that the majority of courseware that is available has largely been written in a machine dependent language and is undocumented and therefore difficult to share. They report that in "The ABC's of CAI" project (47), over 4000 CAI programs written in BASIC were reviewed, and about 3-4 percent were found to be acceptable by faculty in the fields concerned (Chambers & Sprecher,p.338). In short, they are in agreement with Bork who argues that "The notion that computer-based materials can be produced by anybody, completely by themselves, is an archaic concept" (Bork, p.20).

A team approach employing two or three content area specialists, an instructional design specialist, and a computer programmer has been suggested as the only reliable way of ensuring the development of courseware that will be acceptable to faculty and students. Further, it has been found that direct financial reward was not a motivator in involving faculty in developing materials. Rather, as Chambers and Sprecher report, studies have shown that recognition and acceptance by one's peers for courseware development and sharing of such materials, release time, and acceptance of courseware development by peers and by administrators as equivalent to research publications for promotion and tenure, appeared to be the most important incentives in involving faculty members in developing courseware (Chambers and Sprecher, p.339).

Hallworth and Brebner, in their report to the Department of Education in Alberta (23), support the idea of field development of courseware. They argue that "there is a need for a co-ordinated effort within the Province to build effective CAI curricula with many groups contributing and exchanging materials, but with no duplication of effort on any topic because of the exceptionally large numbers of work hours involved" (Hallworth and Brebner,p.215) and they believe that the only way this can be done is through the leadership and support of the Department of Education. They recommend that the Department:

1) facilitate the development of courseware by teams of teachers and other persons having experience in CAI, by appropriate financing including, for example, release time for teachers;

2) monitor such courseware development to ensure continuity of curricula and prevent duplication of effort;

3) set up mechanisms for disseminating information on developments;

4) set up a mechanism for facilitating exchange of courseware, both within and outside the Province;and

5) retain all rights within the public domain (Hallworth & Brebner, pp.215-216).

There is also evidence that the major publishers of educational materials are becoming increasingly interested in developing CAI materials and with their resources, experience, and organization it will likely not be long before there is a substantial number of acceptable CAI programs commercially available. In addition, there are large number of small companies and organizations which have entered the courseware development market. A number of these have not survived a second year in the market, but many are on a second major revision of their materials and have shown themselves to be very willing to listen to the suggestions of teachers and to modify their programs to bring them in line with teachers' expectations. Not only has the quantity of commercially available programs increased dramatically over the past two years, but the quality has improved to such an extent that what was considered to be good a year ago is now considered to be average or below average. New benchmarks in quality are constantly being set and the rest of the market gradually works to that standard until a new level is set.

Thus, if teachers and educational organizations constantly monitor what is commercially available and continually evaluate its applicability to the curriculum, they will be in a position to use what is acceptable in the commercial market and to be able to dtermine areas where support is needed for local development. Dence (17) has argued for the importance of doing more studies on areas where CAI has an advantage over traditional instruction and why it is more effective, and the results of these studies can be used to help educators plan courseware development efforts. This opinion is supported by researchers who argue against "financing an army of CAI authors. A better way, they say, would be to find the areas in which CAI is most effective, and then devise some effective tool for creating and testing good courseware addressed to those areas" (Sugarman,p.29). This argument seems to be supported by the fact that of the approximately 16,000 hours of CAI related materials created for Plato, requiring from 500-800 thousand hours of writing, only 4000 hours are used regularly (Sugarman,p.29).

It would seem that, in the future, a combination of public and private resources will be concentrating on the courseware development problem. By constantly monitoring and evaluating what is commercially available, educators can direct their efforts only to those areas that are not being adequately addressed by the marketplace; and by concentrating their efforts on areas where the research has demonstrated that CAI is more effective and more cost effective than traditional instruction, educators can avoid the time and expense wasted in developing courseware that could have been purchased more cheaply than developed or that is not effective in the instructional setting.

The need for organizations that will provide independent evaluations of programs and professional advice as to the quality of commercially available programs is argued throughout the literature and is a reflection of teachers' need for support in this new and intimidating area of education. As Aiken and Braun (1) argue "teacher acceptance is the biggest challenge facing us today" (Aiken & Braun,p.13).

This appears to be corroborated by Chambers and Bork's study (13) which found that teachers' lack of knowledge about CAI and computers was considered to be a major impediment to the implementation of CAI in the schools, second only to funding. Similarly, Hallworth and Brebner argue that, "CAI will not succeed in any environment where it does not have the full understanding and backing of teachers" (Hallworth & Brebner,p.216); and Clement (14) reports that "Poor attitudes on the part of instructors have actually resulted in covert and in some cases overt sabotage to the computer-aided learning process (Clement,p.28). Teachers need information and knowledge and CAI needs teachers in order to be successful.

Clement believes that "changing most instructor attitudes is a matter of educating them on the adjunctive value of the computer in the learning process" (Clement,p.30), and he suggests pointing out that the computer is capable of taking over the routine, information giving and drill and practice tasks, and the clerical tasks while freeing the teacher to facilitate learning through one-to-one and small-group interactions.

Hallworth and Brebner (23) argue for the importance of educating teachers and providing information, and suggest that demonstration projects, sponsored and supported by the Ministry of Education and in cooperation with an established research center, be set up by teachers who are already knowledgeable about CAI and who can demonstrate the benefits to other teachers. They also recommend that the Ministry not only financially support and publicize the demonstration projects and provide encouragement and high professional status for teachers who demonstrate competence in CAI, but they should also require that new teachers have some knowledge of the use of computers in education. They encourage the Ministry to make computer literacy courses available to teachers at a number of different levels and recommend that such courses be made compulsory.

Aiken and Braun (1) recommend that courses and programs be provided for students training to be teachers, and point out that a way must be found to train the thousands of teachers who are already in the school system. They recommend the approach that the French have taken in training a small nucleus of teachers who are then used to teach others. However, they admit that whatever method is used, it is going to be expensive and a slow process that may require the use of video tape and videodisk as cost-reducing training media (Aiken & Braun,p.13).

Henderson (25) is more specific. He argues that all teachers and educational administrators should complete a minimum of two courses in computer science as a general requirement for certification. He adds that all elementary teachers should complete one additional courses covering the use of CAI materials for the elementary student, and secondary teachers should complete two additional computer science courses covering the use of computer-oriented materials and CAI materials designed for the secondary student and the development of computer-related materials. Administrators, according to Henderson, should be required to take two additional courses relating to the use of the computer in school operations and planning (Henderson, pp.41-42).

Conclusion

A search of the literature regarding the instructional use of computers has revealed that for the most part, researchers are generally optimistic about the future of the computer in education. They feel that the hardware problems are being dealt with and that future advances in technology can only result in what Hirschbuhl terms "Education's Dream Machine". However, it is also generally accepted that the problem of ensuring an adequate supply of quality courseware and of training teachers how to use the computer in an effective manner will continue to impede the widespread integration of computer technology into the school system. It is also generally accepted that solving these problems is going to be expensive.

Until the research can be more specific, it seems reasonable that the resources of institutions, schools and ministries should concentrate their efforts on areas where CAI has proven itself to be both effective and cost effective. In their recommendations to the Alberta Department of Education, Hallworth and Brebner recommend that

> those students who will benefit most from CAI are those for whom the patience and repetitiveness of the computer are of great assistance in their learning, those who require individual attention, those who for some reason have failed to learn in the regular classroom environment, those who feel inadequate and inferior and do not seek help from a teacher for fear of displaying their ignorance, those who do not have ready access to schools, and those studying subjects in which the computational and information processing power of the computer enhance learning (Hallworth & Brebner, p.218).

Further they argue that CAI must be given time to evolve while courseware builds up and irrational fears of computers are overcome. In this way, they believe that "computers should naturally find their place in the educational system."

References

1. Aiken, R.M., & Braun, L. Into the 80's with Microcomputer-Based Learning. Computer, 1980, 13(7), 11-16.

2. Atkinson, R.C. Futures: Where Will Computer-Assisted Instruction (CAI) Be in 1990? Educational Technology, 1978, 18(4), 60-63.

3. Attala, E.E. Futures: Where Will Computer-Assisted Instruction Be in 1990? Educational Technology, 1978, 18(4), 60-63.

4. Bitzer, D. Futures: Where Will Computer-Assisted Instruction Be in 1990? Educational Technology, 1978, 18(4), 60-63.

5. Blaschke, C.L. Microcomputer Software Development for Schools: What, Who, How? Educational Technology, 1979, 19(10), 26-28.

6. Bork, A. & Franklin, S.D. The Role of Personal Computer Systems in Education. Association for Educational Data Systems Journal, 1979, 13(1), 17-30.

7. Bork, A. Machines for Computer-Assisted Learning. Educational Technology, 1978, 18(4), 17-20.

8. Braun, L. Computers in Learning Environments An Imperative for the 1980's. Byte, 1980, 5(7), 6-10, 108-114.

9. Brebner, A., Hallworth, H.J., McIntosh, E. & Wontner, C.J. Teaching Elementary Reading by CMI and CAI. Association for Educational Data Systems, 1980, Convention Proceedings.

10. Bunderson, C.U. Futures: Where Will Computer-Assisted Instruction (CAI) Be in 1990? Education Technology, 1978, 18(4), 60-63.

11. Chambers, J.A. & Sprecher J.W. Computer Assisted Instruction: Current Trends and Critical Issues. Communications of the ACM, 1980, 23(6), 332-243.

12. Chambers, J.A. College Teachers: Their Effect on Creativity of Students. *Journal of Educational Psychology*, 1973, 65(3), 326-334.

13. Chambers, J.A. & Bork, A. *Computer Assisted Learning in U.S. Secondary/Elementary Schools*. Centre for Information Processing, California State University, Fresno CA Research Report No. 80-03.

14. Clement, F.J. Effective Considerations in Computer-Based Education. *Educational Technology*, 1981, 21(4), 28-32.

15. De Laurentiis, E. Learning by Interactive Programming: Microcomputer Applications. *Educational Technology*, 1980, 20(12), 10-14.

16. Deignan, G.M. & Duncan, R.D. CAI in Three Medical Training Courses: It was Effective! *Behaviour Research Methods and Instrumentation*, 1978, 10(2), 228-230.

17. Dence, M. Toward Defining a Role for CAI: A Review. *Educational Technology*, 1980, 2011), 50-54.

18. Eisele, J.E. A Case for Computers in Instruction. *Journal of Research and Development in Education*, 1980, 14(1), 1-8.

19. *Academic Computing in Saskatchewan: A Status Report*. Exploratory Committee on the Academic Uses of Computers in Saskatchewan, 80 01 12.

20. Gershman, J., & Sakamoto, E. Computer-Assisted Remediation and Evaluation: A CAI Project for Ontario Secondary Schools. *Educational Technology*, 1981, 21(3), 40-43.

21. Gleason, G.T. Microcomputers in Education: The State of the Art. *Educational Technology*, 1981, 21(3), 7-18.

22. Hallworth, H.J. & Brebner, A. CAI for the Developmentally Handicapped: Nine Years of Progress. *Proceedings of the 1980 Conference of the Association for the Development of Computer-Based Instructional Systems*, 1980, 260-265.

23. Hallworth, H.J. and Brebner, A. *Computer Assisted Instruction in Schools; Achievements, Present*

Developments and Projections for the Future. Calgary: Faculty of Education Computer Applications Unit, 1980.

24. Haugo, J.E. Management Applications of the Microcomputer: Promises and Pitfalls. Association for Educational Data Systems, 1981, Convention Proceedings, 129-132.

25. Henderson, D.L. Educational Uses of the Computer: Implications for Teacher/Administrator Training. Educational Technology, 1978, 18(8), 41-42.

26. Hirschbuhl, J.J. Futures: Where Will Computer-Assisted Instruction (CAI) Be in 1990? Educational Technology, 1978, 18(4), 60-63.

27. Hirschbuhl, J.J. Hardware Considerations for Computer-Based Education in the 1980's. Journal of Research and Development in Education, 1980, 14(1), 41-56.

28. Holznagel, D.C. MicroSIFT -A Clearinghouse for Microcomputing in Education. Association for Educational Data Systems Monitor, November 1980, 16-17.

29. Kearsley, G.P. Some 'Facts' About CAI: Trends 1970-1976. Journal of Educational Data Processing, 1976, 13(3), 1-11.

30. Kniefel, D.R. & Just, S.B. Impact of Microcomputers on Educational Computer Networks. Association for Educational Data Systems Journal, 1979, 13(1), 41-52.

31. Lavin, B.F. Can Computer-Assisted Instruction Make a Difference? An Analysis of Who Benefits. Teaching Sociology, 1980, 7(2), 163-179.

32. Luehrmann, A. Computer Literacy - A National Crisis and a Solution For It. Byte, 1980, 5(7), 98-102.

33. Luehrmann, A. Computer Literacy - What Should It Be? August, 1980. (published???)

34. Magidson, E.M. Issue Overview: Trends in Computer-Assisted Instruction. Educational Technology, 1978, 18(4), 5-8.

35. Molnar, A.R. The Next Great Crisis in American Education: Computer Literacy. *Association for Educational Data Systems Journal*, 1978, 12, 11-20.

36. Molnar, A.R. Understanding How To Use Machines to Work Smarter in an Information Society. National Science Foundation, November 1979.

37. Moursund, D. Microcomputers Will Not Solve the Computers-In-Education Problem. *Association for Educational Data Systems Journal*, 1979, 13(1), 31-39.

38. Moursund, D. Personal Computing for Elementary and Secondary School Students. *Point Paper for National Computer Literacy Conference*. December 1980.

39. Norris, W.C. Via Technology to a New Era in Education. *Phi Delta Kappan*, 1978, 58(2), 451-453.

40. NCSM National Council of Supervisors of Mathematics Position Paper on Basic Skills, January 1977.

41. Paden, D.W., Dalgaard, B.R., and Barr, M.D. A Decade of Computer-Assisted Instruction. *Journal of Economic Education*, 1977, 9(4), 14-20.

42. Pamphlet, Deltak Inc., Oak Brook, Illinois, 1981.

43. Rawitsch, D.G. Implanting the Computer in the Classroom: Minnesota's Successful Statewide Program. *Phi Delta Kappan*, 1981, 62(6), 453-545.

44. Sandals, L.H. Computer Assisted Learning With Handicapped Children and Adolescents and those Students with Learning Problems. *Proceedings of the Third Canadian Congress of the Council for Exceptional Children*, 1978, 225-230.

45. Splittgerber, F.L. Computer-Based Instruction: A Revolution in the Making. *Educational Technology*, 1979, 19(1), 20-26.

46. Sugarman, R.A. A Second Chance for Computer-Aided Instruction. *IEEE Spectrum*, August, 29-37.

47. *The ABC's of CAI*, Fourth Edition, California State University, Fresno, California, 1979.

48. Travers, J.G. Development of a Microcomputer

Implementation Model: An In-Situ, Adaptive Research Paradigm. Master's Thesis, University of Alberta, 1981.

49. Van Dusseldorp, R. Alaska On-Line Resource Information Bank. Association for Educational Data Systems, 1981, Conference Proceedings, 263-266.

50. Watt, D.H. Computer Literacy: What Should Schools Be Doing About It? Classroom Computer News, 1980, 1(2), 1,26-27.

51. Watt, D.H. Education for Citizenship in a Computer-Based Society. Invited Presentation at a Conference Sponsored by the National Science Foundation: National Goals for Computer Literacy in 1985, December 18-20, 1980, Reston Virginia.

52. Watts, N. A Dozen Uses for the Computer in Education. Educational Technology, 1981, 21(4), 18-22.

53. The potential teacher population was difficult to ascertain and was judiciously overestimated in an effort to include every teacher who had exposure to the pilot project no matter how limited that exposure may have been. See Appendix 1.

54. Secondary is used as the generic term for grades 8-12: elementary for grades 1-7. More specifically, primary is used for grades 1-3; intermediate 4-7; junior secondary 8-10; and senior secondary 11-12.

55. Figures 14 & 15 are taken from item #5 of the coordinators' questionnaire and item #8 on the teachers' questionnaire. These items were used instead of items #20-22 for the coordinators and #26-28 for the teachers due to the typing error explained in Appendix 1.

56. The data represents item 6b on the teachers' questionnaire which was used instead of item 5c for the reasons mentioned in Appendix 1.

57. The percentage of teachers matrixed on cost-effectiveness is based on a small number of responses which suggests that the majority of teachers could not respond to this question.

APPENDIX

SUMMARY REPORT: B.C. RESEARCH

MICROCOMPUTER PILOT SURVEY: TEACHER'S QUESTIONNAIRE

Summary Report

June 1981

Return Rates

A total of 117 completed questionnaires were included in the final analyses. These represent 60.3% of the questionnaires mailed out. As I mentioned in a previous conversation with Debbie, since lists of teachers' names were received from only four school districts, the questionnaires were mailed to the other eight coordinators for distribution. In many cases a rather liberal estimate of the number needed was sent: as a result the actual return rate may be higher, but we have no way of knowing what it is. When, however, the return rate is calculated for those four districts whose questionnaires were mailed directly to the teachers the figure is 72.7%. The direct mailing route is always more preferred and it's unfortunate that we weren't supplied with more of the requested lists. Return rates per school district are listed below.

#68	Nanaimo	70.0%	mailed directly to teacher
#37	Delta	100.0%	
#38	Richmond	86.7%	
#22	Vernon	61.8%	
#42	Maple Ridge	76.7%	distributed by coordinators
#15	Penticton	30.0%	
#48	Howe Sound	60.0%	
#88	Terrace	33.3%	
#61	Victoria	55.0%	
# 9	Castlegar	65.0%	
#60	Peace River North	30.0%	
# 3	Kimberley	40.7%	

"Level" Designation

For questions 1, 3, 4, 5b, 6a, 6b, 7 and 20 results are reported for both the total sample and for the sample broken down by level as follows:

PRIM	(Primary)	Kindergarten, Grades 1-3
INTER	(Intermediate)	Grades 4-7
JRSEC	(Jr. Secondary)	Grades 8-10
SRSEC	(Sr. Secondary)	Grades 11-12

Opinionaire Questions 26, 27 and 28

The majority of the questionnaires were mailed out with an unfortunate typing error which presented the first (as well as the last) option as "Very important". Although this was followed with an errata notification and some corrected versions were mailed at a later date, the inconsistency reflected in the data in comparison to question 8 suggests that options 1 and 5 for these questions were confused.

I personally apologize for the error and recommended use of question 8 data rather than these three. There is no doubt, even with the error however, that microcomputer instruction is considered important to very important at all levels, and increasingly so the higher the level.

Please note that the same error appeared on the Coordinator Questionnaire, Questions 20, 21 and 22.

Crosstabulation Results

The 'crosstabs' analyses in the computer printout (pages 242-337) present 2-way joint frequency distributions relating responses on selected questions to the level at which the microcomputers were used (PRIM, INTER, JRSEC, SRSEC), rated satisfaction with the project (question 25), and personal computer literacy (question 20). Relatively few of these produced significant results at the p<.01 level. They are summarized as follows.

Q1 (p.242) There were more microcomputers available at the secondary than the elementary levels.

Q8 (p.244) All of the elementary teachers felt that microcomputers should be introduced at the elementary level while some secondary teachers felt that the introduction should be introduced at the junior secondary level.

Q9 (p.245) At the elementary level, almost all microcomputers were located in classrooms or libraries, with the majority being in classrooms.

At the secondary level, the locations were fairly evenly split between classrooms and labs: no libraries were used.

Q11.B.8 & Q11.B.9 (p.255-256) The only noteworthy dissatisfaction reported with both district and Ministry level coordination was at the junior secondary level. Twenty-five percent of those teachers reported district level dissatisfaction and 28.6% reported Ministry level dissatisfaction. Interestingly, there was no dissatisfaction reported from senior secondary teachers.

Q12.C.5 (p.267) The majority of primary, intermediate, and junior secondary teachers reported microcomputer courses to be less effective or as good as traditional instructional approaches. It's interesting to note that there was less satisfaction for intermediate and junior secondary than for primary teachers.

The majority of senior secondary teachers reported microcomputer courses to be as good as or better than traditional methods. This no doubt reflects differences in the type of courses offered.

Q15 (p.270)	At the elementary levels the major use of microcomputers is to augment traditional instruction. As grade level increases, so does the percentage of time devoted to new instruction. While no primary teachers used microcomputers for new instruction, the majority of senior secondary teachers reported that use.
Q16.3 (p.273)	The higher the grade level, the greater percentage of teachers reported having taken university or college computer courses. This ranges from 0% of primary teachers to 50% of senior secondary teachers. Considering the interest stated in introducing microcomputers in elementary school, teacher training institutes should start offering courses for these teachers as well!
Q19.1 (p.284)	More emphasis in learning to assemble the components of the Apple system was suggested by secondary than elementary teachers. Obviously, teachers with more skill and experience have more interest in this aspect of computer use.
Q20 (p.293)	Secondary teachers rated their own level of computer literacy than elementary teachers. Increasing teacher literacy is associated with higher grade levels taught.

Please note that it is not necessary to have statistical significance to report trends or differences where there may be data of interest. It is advisable, though, to state that any such findings do not represent significant differences.

To aid in your own interpretation of the statistics associated with the crosstabs tables, definitions are included for chi-square and Cramer's V.

Chi-square tests for the existence of a systematic relationship between two variables by comparing cell frequencies which would be expected when no relationship exists to actual cell frequencies. The greater the discrepancy between the expected and actual frequencies, the larger chi-square becomes. Therefore small values of chi-square indicate the absence of a relationship whereas high values imply that a systematic relationship exists between variables. It does not measure the strength of the relationship.

Cramer's V does provide a measure of the strength of that relationship. V ranges from 0 to +1 with values approaching 1 signifying that a high degree of association exists. Experience suggests that values above .1 may be meaningful.

Number of Students per Microcomputer (Question 5c)

I recommend caution in using these results since the range of responses within each category (i.e. box) was generally very large. My guess concerning the reason for this is that the interpretation of the question's intent varied across respondents. For example, sections 9, 10, and 11 appear to have been answered with respect to both how many people should operate the microcomputer for such uses, in which case the numbers were very small (1-4), and how many students should be served by such uses, in which case the numbers were very large (as shown). Several people wrote in "1 per school" for these categories and I imagine that would represent the general intent. It is, nevertheless, difficult to make a good interpretation as the data exists. I have included average numbers for sections 1 through 8 since there was reasonable consistency in them and since the ranges were much less than those discussed above.

Barbara Holmes

Barbara Holmes
June 18, 1981